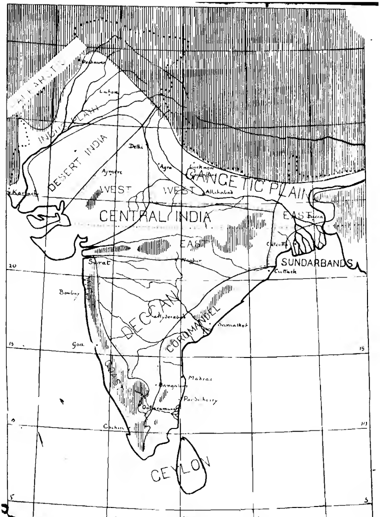

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FRONTISPIECE.

MAP OF INDIA.

THE black shading indicates the Himalayan and Palearctic portions to the North and, in India, areas above the dividing line of tropical and sub-tropical India, usually above 2,000 feet. The dotted black line to the North is the political boundary, inclusive of Cashmir and Sikkim. The red lines and lettering indicate the faunal zones of Tropical India as described in the Section on Geographical Distribution below. The dotted lines dividing the West Coast indicate probable sub-regions and correspond to the Palghat and Goa gaps in the Ghauts. Sub-tropical faunal zones are not indicated.

18668. 11.

INDIAN INSECT LIFE

A MANUAL OF THE INSECTS OF THE PLAINS

(TROPICAL INDIA)

BY

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To
My Mother

" Plus je connais les peuples,
Plus j' aime les insectes."

ACKNOWLEDGMENTS.

The sections on *Mallophaga*, *Diptera*, *Cimicidæ* and *Anoplura* have been prepared by Mr. Howlett, and the Interlude on Insects and Flowers by Mr. I. H. Burkill, Reporter on Economic Products. Illustrations marked I. M. N. are from the stock of drawings accumulated by my predecessors in the Indian Museum, and used in Indian Museum Notes. Those marked F. M. H. have been drawn by Mr. Howlett, who has directed the preparation of those illustrating the sections he has written. Where not otherwise acknowledged, all the plates and illustrations are the work of the Artist staff of this Institute under my or Mr. Howlett's direction; it may be pointed out that these artists are wholly Natives of India, trained in Art Schools of this country; it is needless to emphasise how much the book owes to their beautiful work as also to the enterprise of the publishers, who have done the work of reproducing all the illustrations in this country. I wish to specially express my appreciation of the work of Mr. Slater of the Calcutta Phototype Company in the printing of the Colour Plates, carried out under very trying climatic conditions and for the first time in this country.

As regards the text, it is, where not stated to be a quotation, original; I have acknowledged every direct source of information. The book owes something to the work of my staff, since it is based on the Pusa collections to which they have contributed specimens and observations. I have acknowledged this where I can. The volume is largely a product of my spare time and scanty holidays; such a volume has been so much required that I have felt that even an imperfect one was better than none. Six years ago the work of this section commenced and if the book contains imperfections, the critic will recognise that it is based on collections, observations and reference books that have been accumulated only in that short time; I shall be glad if those who see omissions or errors will point them out, as it may be that a better volume will be built up on this basis, when the study of Indian Entomology is further advanced. I may also emphasise the fact that where little is said, little is known and the blanks in the book are designedly prominent to emphasise the enormous scope there is for work. I trust also that the volume may be a real stepping-stone to better things and may help those who are advancing our knowledge of the insect life of India.

PUSA:
June, 1909.

H. M. L.

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SCHEME OF CLASSIFICATION.

The following is a complete list of the families into which insects are divided, tabulated under orders. The families in heavy type, thus **Forficulidæ** should be familiar; those in ordinary type, thus Campodeidæ, are of smaller importance but occur in India: those in italics, thus *Smynthuridæ,* are not yet known to occur in India.

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INDIAN INSECT LIFE.

INTRODUCTION.

THE insects are tracheate, hexapodous arthropoda, with a distinct head bearing antennæ, with a great degree of complexity in their development during which a series of moults are undergone, culminating in the appearance of functional generative organs and wings; in the higher forms, the development is sharply divided into three distinct periods, the last of which is marked by the inactivity of the organism as a whole and the complete reorganisation undergone by the tissues; they are essentially air-breathing animals, living on land, but some have become adapted to living in fresh water. The number of jointed legs separates them clearly from other tracheate Arthropods, just as the metamorphosis, the possession of wings and the form and the number of segments does. They are regarded as being most closely related to *Peripatus* of all present forms of life, and undoubtedly represent a great branch of the tree of life whose development equals, if not excels, that of any other branch. In numbers, in species, in all but one form of mentality, the insects are the dominant form of life on the land at the present time, but the limitations put on them are of such a nature that their dominance must remain within bounds and, unless man be removed, cannot be actual and entire.

Insects are of all sizes from $\frac{1}{50}$th inch long to over six inches; their numbers are incalculable, the number of their species being put at about three millions; their lives are very short, (a week,) up to as long as over ten years, though rarely actually exceeding more than three years, and being in the larger number limited to an active life of less than three months. On the surface of the earth, as in fresh water, they are found wherever nutriment is available, even in the bodies of warm-blooded animals and man; over the three-fourths of the earth's surface covered by the sea they are practically non-existent, a very small number of species being able to support life near, in or on the sea. Their position in the animal world is shown in the table :—

- PROTOZOA.
- PORIFERA (Sponges).
- CŒLENTERATA (Anemones, etc.).
- CTENOPHORA (Jelly-fish, etc.).
- ECHINODERMATA (Sea-urchins and starfish).
- VERMES (Worms).
- POLYZOA.
- ARTHROPODA.—Crustacea (Lobsters, etc.)
  - Prototracheata (Peripatus).
  - Myriapoda (Centipedes and millipedes).
  - Insecta (Insects).
  - Arachnida (spiders, mites, scorpions, etc.).
- MOLLUSCA (Snails, etc.).
- BRACHIOPODA.
- CHORDATA.—Hemichordata.
  - Tunicata.
  - Cephalochordata.
  - Craniata. Cyclostomata.
    - Pisces (Fish).
    - Amphibia (Frogs).
    - Reptilia (Snakes, etc.).
    - Aves (Birds).
    - Mammalia (Mammals).

Economically, the insects are the most important group of animals next to the Mammals, Birds and Fishes. Their activities affect man daily, either from the nature and extent of their injuries to economically valuable plants, or to domestic animals, or to wild animals, or to stored produce, or from their value in yielding useful products; or from the part they play in the economy of nature, in fertilising flowers, in scavenging and cleansing the earth, in rendering waste matter available as plant food, in preserving the condition of the soil and in furnishing food for birds and fishes.

INSTINCT AND HABIT.—What is the life of an insect? In what way can it be compared with our own or with the life, for instance, of any of the animals familiar to us? No answer can be easily given, for the senses, the instincts, the modes of expression of insects are so totally diverse from our own that there is scarcely any point of contact. In the case of mammals, of birds and to some extent of reptiles, we have in the eyes, in the features and in the movements, a clue to their feelings, to the emotions that sway them, to the motives that guide their actions; in insects we have none, and the great index of insect feeling, the antenna, has no counterpart in higher animals, and conveys nothing to our uninformed brains. We can judge then only from the movements of insects, from their actions, and this is so extraordinarily meagre a clue that it is not surprising that even the greatest familiarity with the life of an insect inspires no feeling that one has to do with a live organism having feelings and passions, having motives and a will, but suggests that one has before one a beautiful machine, tuned to respond mechanically to certain outside stimuli, to answer to particular influences and to behave in all things as a perfect mechanical structure; even the highest, the social insects and the fossorial wasps, inspire no other feelings, give one no sense of any relations between the individual insects but those mechanical ones concerned with daily life, and leave one with the conviction that the mentality of the higher animals is wholly absent, that no smallest trace of the emotions, of the will, of the thought processes of ourselves or other mammals, have any part in the lives of insects. Yet there are events in the lives of insects which, for a brief moment, impress us with the conviction that individuality, emotion and feeling may play their part; and though we see this exceedingly seldom, the few suggestive phenomena may be sufficient to warrant the assumption that in ways we cannot comprehend, in channels that are beyond our ken, the living active insect is in touch with every other living insect in its environment, by mental and physical processes that make no outward sign, that may proceed independently of any external sense organ that we can see or study and which possibly pass from mind to mind with no outward physical action or movement; what occurs when bees swarm, when locusts swarm, when the white ants emerge from the nest, when a stray bee from one nest enters another and is promptly attacked and killed? Are these wholly due to reflex actions and mechanical instincts, or are they the product of an individual will and mind in each and every insect; a locust swarm may be the product of a blind impulse sweeping over a host of insects just as a blind impulse ranges through a crowd of human beings by means which are certainly not normal or in daily use; the emergence of the flying ants suggests a similar blind impulse, an unreasoned compliance with fixed instincts like the blowing up of a boiler when certain physical conditions are arrived at: do the ants have councils and decide when the nest shall be moved to a new locality, or is it simply the common impulse of the community, simultaneously born of the same reaction to certain physical conditions? So wide apart are our senses from those of insects, so divergent are our means of expression, and the mechanism of our bodies, that no answer can be given to these questions; we cannot establish any connection with the individuality of insects, we can get no common basis of thought, no possible means whereby even to "tame" them or to get even so little response to our efforts as a tame bird will give. To us, the closest study of large numbers of the same species reveals no individuality, nothing but a mechanical sameness in a large number; perhaps this is because we cannot get near enough; to the ordinary man, sheep are sheep and while differing in small points are alike; to the shepherd they are as individual as human beings and have a similar mental individuality; I have never seen that this was the case with insects, and none that have been kept in activity, fed, cared for and most closely observed, have shown more than very small traces of individual mentality or even responded to advances. (That this is not the view every author takes is evident from the writings of naturalists who state that butterflies in particular become tame and welcome their captor's visits; but these cases are not sufficiently numerous or well authenticated to be valid.) It is not unreasonable to consider that, in freedom and living under natural surroundings, nearly every insect is solitary; an individual insect appears to take no notice of any other, save such as it may prey on or parasitise; it goes about its business of food-getting and the like, it makes no smallest sign that it is aware of the existence of any other insect, and so far as can be judged from its actions, is leading an absolutely and wholly solitary life; there are exceptions, of course, but very few; the social insects are apparent exceptions, but even there it is extremely doubtful how far individuals are not isolated; they work together it is true, but in a manner that suggests two machines under the same controlling conditions, not two sentient reasoning organisms acting in agreement due to any mental process. The same is true of termites, of locusts, of all the social insects which exhibit such wonderful phenomena. The Pyrrhocorid *Iphita limbata* is gregarious and lives in colonies on the bark of trees; is there any communication, any individuality, any mental process other than a blind reaction to some outside stimulus, under which all alike find that a particular spot is perhaps the warmest or the best suited for some such reason? There are other exceptions which are perhaps more valuable; the courtship of butterflies is a beautiful thing, suggesting two perfectly happy beings enjoying to the full the delights of each other's company and the perfect happiness of the crowning moment of life; there is no doubt of their being aware of each other's presence, but the cold thought creeps in that it is after all a mechanical process, born of peculiar instincts, with nothing more "living" than the reaction of two parts of an engine. The dances of flies and other small flying insects suggests mentality, social insects thoroughly enjoying each other's company and the extraordinary pleasure that human beings find in concerted movement; it is possible that we can compare insects with ourselves in this respect, but the balance of evidence is certainly against it; one comes inevitably to the feeling that insects are a supreme expression of living matter adapted and co-ordinated to physical conditons, responding perfectly to mechanical stimuli, without mind or mental processes as we know them and as we can see them in birds and mammals; they are the highest expression of life as evolved by natural processes, perfect machines without emotions. No thinking man questions the existence in higher mammals of mind-processes akin to our own if far lower, of some slight evidences of that higher mentality we call the soul, and which we hold to be the essential life, for which the objective life and the material body is but a case. No one would credit an insect with such forms of mentality, and the most sympathetic student of insect life has not advocated such a point of view. An insect is a living machine, responding to definite physical stimuli, with well-defined and very complex instincts, which are mechanical forms of mental action and take their origin in outward conditions. Were they possessed of higher forms of mentality, such as reason, judgment, volition and the like, no one can say what might be the course of the world's history; a combination of the red ants (*Œcophylla smaragdina*) could probably drive human beings out of India and render the continent uninhabitable to any form of life inimical to them ; an organised campaign of the common black ant (*Camponotus compressus*) could effect a great deal and human methods of warfare would require to be revolutionised to deal with it.

In practice we can consider insects as consisting of organisms whose actions will be definite responses to stimuli, whose movements and activities will, under the same circumstances, be the same ; given the same conditions, all the individuals of a species will behave alike with only very minute variations which we have great difficulty in seeing. If we find that one of a species has a certain definite life history we are safe in concluding that under the same circumstances all of that species will have the same life history and that with a given departure from normal circumstances all will behave alike ; when we have worked out the life history and habits of one of a species, we can confidently assert that all will have that life history, with only small variations due to changed conditions ; a leaf-eating caterpillar that feeds on maize leaf in Behar, might quite well feed on juari leaf in Gujarat where maize is not grown, but it would not, for instance, become a borer in the Punjab and a predaceous caterpillar in Madras. We may, therefore, treat a species as an individual, and not expect to find different habits in different individuals of the same species. At the same time we must allow for the variation consequent on changed conditions ; the limit of adaptation to changed conditions is a very variable one ; as an example, many caterpillars have but a very few foodplants and cannot live on others ; a few have many, and the Gram Caterpillar (*Chloridea obsoleta*) feeds on the seeds of gram, the heads of opium poppy, the heads of bajra or sunflower and a variety of other plants ; in the United States it is the boll worm feeding on the seed of cotton and accordingly has slightly different habits ; in this there is a certain amount of variation in habits due to changed foodplants. Such cases are frequent, but the variety of habits lies within perfectly clear and definite limits, varying slightly from species to species. On the above reasoning, a species is definable not only on structural characters but also on its habits and mode of life ; if we look on a species as composed of individuals reacting mechanically to stimuli, with a limited play of adaptation to changing conditions, habits and mode of life are as much specific characters as is structure ; if our structural distinctions are sound, they will be in agreement with habits and life history, and the one aspect is as important as the other. Our knowledge of structure is far greater than our familiarity with the habits of insects, but the latter will increase. It is all important for the student to grasp clearly from the beginning that a "species" is a distinct individual as much in habits, mode of life and all details of its life as in its colour, form, or any structural detail on which it is declared to be a distinct species. We are here far more concerned with the living insect as a living reality than with the dead shell on which its place in the insect world is determined and on which it is described and named; the characters of the living insect, its method of flight, its walk, its feeding habits, its expressive antennal movements, all the details of its daily life are of as great value as its structure and are of far greater importance to us in these pages; a realisation of this fact and an understanding of what a species really is, must come to every student sooner or later if he is to become anything more than a systematist and a classifier of insects on purely structural details; the individuality of a species is as much discernable in the field as in the museum and takes in every detail of the insects life. For that reason, we have considered this abstruse point at some length and we would emphasize the point of view given, though it may seem at first sight an incorrect one. Variations in habits between two members of a species are so small that what we find out of a single individual, applies to every individual of that species with due allowance for variable conditions; a very large part of our work lies in determining how far different conditions modify the habits of an insect and the limits of this variation are becoming clearly established; if, therefore, the habits of an insect are observed in Peshawar, we know that the individuals of that species will have in the main the same habits at Madras, that we can predict the variations likely to be found, and that if we knew enough we could absolutely say how far they would differ.

We may touch very lightly upon one more point; whence come the instincts and beautiful habits of our present-day insects? According to the accepted theories of evolution, insects, like other animals, are descended from more primitive forms of life which existed in earlier geologic periods; if we imagine the primitive types of insects being evolved and multiplying, and supposing them to feed on the abundant decaying vegetable matter, we shall get a great development of simpler forms scattered over large areas of land, and living in a diversity of physical conditions; remembering their less specialised and complex structure, we can see that the influence of altered conditions might produce great variations in structure, in habits, in life history; the pressure of competition would arise, supposing there were fewer checks: (what checks there may have been is doubtful but both parasitic and predaceous insects, as well probably as insectivorous birds arose later and these are now the main checks); some, from feeding on decaying vegetable matter, might come to feed on decaying animal matter, with a consequent change of habits, of structure, of senses, possibly of life history; others might find growing plants provided an ample supply of food and their descendants gradually get modified to suit these circumstances; in time we can imagine some becoming predaceous, the descendants perhaps of insects that fed on dead insects; we can still see the stages between land and aquatic insects, and it requires little imagination to picture the necessary gradations from an insect feeding on decaying leaves by a riverside, to one that entered the river water and found its food there. Given a plastic structure capable of modification, granted growing competition and a free unoccupied field, one can readily see how, in earlier ages, the various groups may have arisen: with the altering conditions of successive geologic periods, with the evolution of higher plants and animals, with alterations of climate and natural conditions, one can realise how the diversity of forms of insect life would be evolved. That this has occurred with other forms of life one can read; that the steps cannot be traced so clearly in insects is due to the imperfection of the geological record, insects being small, soft and not so fitted for preservation as are bones or shells. Granting that in previous ages this occurred, and seeing the present dominance of insect life on the earth and in fresh water, it is easy to see that the competition might be so severe that more and more complex structures, instincts and habits might be evolved leading steadily away from plasticity to more and more fixed and unalterable types; the more primitive and simple insect feeding on decaying leaves, having simple biting mouthparts, laying eggs in the ground, requiring no special colouring or protective devices disappeared; predaceous insects require more complex trophi; quick flight necessitates better wings and a more consolidated thorax; protection from birds implies protective attitudes, colouring or form, and may require possibly the nocturnal habit, which implies better sense organs; all crystallises down to a specialised form with fixed instincts. So too, for instance, with parasitic insects, the new habits imply new structure, the petiolate body and the ovipositor are developed to lay the eggs, and with the necessity for flying by day comes warning colouring and unpleasant taste or odorous glands, since birds are developed also and are taking to eating insects. Consider a Sphegid catching live insects, paralysing them, laying them up for its young: imagine the development of such forms, the gradual acquirement of more and more perfect structures, and with them of more and more fixed instincts till we have the perfect insect, with intensely modified life history, with fixed and complex structure and with nearly *all plasticity and power of change gone.*

This is the point I wish to make; we are now at a stage in the earth's history when competition has produced an amazingly complex number of forms of insect life, which adapted themselves to every condition of life but that in saltwater, which have, by the improvement of more and more perfect forms, become increasingly complex, specialised and fixed: variation, except in each special direction, makes for destruction; from the increasing competition plasticity is gone, the forms are fixed and unalterable, and what may once have been forms of active mentality implying some choice, some volition, are now fixed instincts, crystallised reflex and, possibly, voluntary actions. It is true that all are not equally complex or specialised, but I believe it to be true that almost all, simple or complex, are fixed, are no longer alterable except so minutely and so slowly that we can no longer see it. It is questionable whether there is any form with which we could people a part of the earth, say an island, that was absolutely devoid now of insect life, and in which we could see this process of differentiation and specialisation take place, but could we find such a form, could we give it the same free field and let it multiply and increase, we should get a similar differentiation and an ultimate specialisation of equally fixed forms.

The student may read this for himself at greater length in text-books of palæontology, geology and evolution; he must realise it if he is to grasp the meaning and origin of the forms and habits of insects; and in no other group is it so marked as in insects; when we consider the abundance of forms of life in the insect world, their absolutely universal occurrence on land and in fresh water, the extraordinary variety in habits, food and ways of life, as compared with any other group or with all groups together, we can see that in no other class in the animal world is competition so keen, are instincts and habits so fixed, is the whole of life for each species so unalterable and delicate. Insects have lived, have dominated the earth, have become what we see them by carrying to an extreme the principle of adaptation to circumstances, of making the most of natural conditions; man has become what he is, because he has carried to an extreme the principle of adapting natural conditions to himself while only adapting himself to them to a limited extent; the two classes dominate the land, and when man cannot alter the conditions to make life permanently bearable, insects can adapt themselves and do. But in the process man has developed one form of mentality implied in the terms free-will, choice, volition, while insects have become perfect mechanical structures reacting in a definite way to natural forces and stimuli, their lives ruled by fixed and most perfect "instincts."

It is not my intention to give the impression that instincts are *absolutely* fixed but only that they are fixed as compared with the plasticity of earlier insects and as compared, say, with man. There is a certain latitude still, more in some groups than in others, but even in them not much and in the most specialised probably very little. I imagine that such simple forms as *Machilis* are fixed in their simple habits as compared with a Sphegid fixed in complex habits, but to both there is a certain small latitude within which they can still alter. The instincts of a polyphagous caterpillar such as *Chloridea obsoleta* are probably much less fixed and specialised than are the instincts of the caterpillar of *Scirpophaga auriflua*, for instance, and in each case possibly their degree of specialisation, low or high, makes for success, success being purely the ability to get food and lay eggs freely. Some are successful because they are fixed in delicate mechanical instincts, notably the insect-stinging wasps; others are successful because they can adapt themselves still to a limited variation of circumstances, such as food, temperature, etc., and they are still to some extent plastic. But it is a very limited plasticity, little akin to the plasticity of the earlier forms from which our present insect life has arisen.

CLASSIFICATION.—When insects were first studied in some detail, the complexity of the increasing number of recorded species led to a system of grouping, say, the beetles under one title, the moths and butterflies under another, and so on, the insects most obviously similar being put into one group chiefly as a matter of convenience. As the subject grew, the morphological characters of the collected insects were utilised to an increasing extent, and the more the number of known insects increased, the more minute and detailed was this classification. When the evolution theory was accepted, it was evident that every scrap of available information would be required to give data on which to make a natural grouping of insects; what was the origin of insects? from what had they developed? how far had different insects remained for a long period in the same condition. and how far was the evolution either continuing still or had it been continuous up to the recent past? These were the questions to be answered, and the answer is embodied in the present-day system of classification which is believed to be so far natural that it conforms, as far as possible, to the actual developments of insects during the earth's history and does represent actual relationships. On these terms all the members of one group are more closely interrelated than each one is to any other insect not in that group.

In making this classification, there are practically three main sources of evidence: (1) the morphology of the insect in all its stages; (2) the processes of embryological and post-embryological development; (3) the evidence of fossil and extinct insects.

In the beginning, the first alone was utilised, and it is still the main source of information: at first superficial characters were used, then more detailed ones such as the structure of the trophi, finally the fuller evidence afforded by all parts of all stages is being utilised, though this is by no means near completion. The second has been utilised, but not to a great extent. The third has been utilised as far as it is available, but the geological record is scanty, and what there is, is very imperfectly available as yet. There is a great bulk of literature on this question, and it is impossible to more closely enter into the subject here. How little is really known can be gauged from the great changes made in the classification of Heterocera, for instance, as well as from the fact that entomologists have arrived at no definite conclusions which are generally accepted. The most diverse views prevail, and there is no standard classification that is or can be universally employed even if it be admittedly not academically accurate, but sufficiently so for practical purposes. As knowledge grows, as groups are revised, new views are expressed, new systems adopted. This would matter little if there were, for instance, agreement as to one unit, say the family, if it could be decided that Coleoptera, for instance, are a homogeneous group of say 80 families: unfortunately this is impossible at present. Actually, insects are primarily divided or have been divided into primary divisions called orders. Thus Coleoptera are a distinct enough order; when we go below this, we should have a definite number of sub-orders, each containing a definite number of families; the sub-family is the next division containing a number of genera. Unfortunately superfamilies, legions, cohorts, tribes, etc., have been used, and it is rare to find all authorities on an order or sub-order using the same classification.

In this volume, we propose to follow the Fauna of India, in using the terms order, sub-order, family, sub-family, division, genus, species, but as classification is not our main object, we can largely simplify the system actually used in the Fauna.

Entomologists have adopted the family as the unit of classification trying to group insects first into divisions which must have had a common ancestor; on this basis we get nearly 300 families, each of which represents a fairly homogeneous assemblage, derived from one branch of the tree; the difficulty is greater when we try to group these families to find the main limbs of our tree or to find how many separate limbs we should have, derived each from some lower form of life; for instance, Lepidoptera are a very homogeneous order, the families derived from one branch; Orthoptera on the other hand are by no means uniform, and so far as can be seen, the order instead of coming from one branch may really come from three; none the less, in the absence of sufficient data to find really how many branches there are, the order Orthoptera as here adopted is a very convenient one. Our nine orders are constituted then with a regard both to truth and convenience and a student should think in terms of families, grouping these families into aggregates which we may call sub-orders and orders.

In practice we have to utilise a conventional system that embodies as much truth as possible and which is reasonable for working purposes.

Of the nine orders we adopt here, seven are generally accepted by entomologists, but there is great divergence of views over the *Neurop-*

tera. With regard to this, the following tables show the terms used by other authors :—

Orders.	Sub-orders.	Families.	Smith's orders.	Woodworth's orders.
NEUROPTERA	Mallophaga.		Mallophaga.*	
	Pseudoneuroptera	Embiidæ.*		
		Termitidæ ..	Isoptera ..	Corrodentia.
		Psocidæ ...	Corrodentia.*	
		Perlidæ ..	Plecoptera.*	
	Amphibiotica ..	Odonata ...	Odonata. ..	Odonata.
		Ephemeridæ .	Ephemerida ..	Ephemerida
		Sialidæ ...	Platyptera *	
	Planipennia	Panorpidæ ...	Mecoptera.*	
		Hemerobiidæ	Neuroptera.*	*Neuroptera.
	Trichoptera ..	Phryganeidæ	Trichoptera.*	

We believe the most logical and workable system of insect classification to be the following :—

1. APTERA.
2. FORFICULIDÆ.
3. BLATTIDÆ.
4. ORTHOPTERA (5 families).
5. TERMITIDÆ.
6. MALLOPHAGA.
7. PSEUDONEUROPTERA. (Embiidæ, Psocidæ).
8. NEUROPTERA AMPHIBIOTICA.
9. NEUROPTERA PLANIPENNIA.
10. TRICHOPTERA.
11. HYMENOPTERA. PHYTOPHAGA. (Sessiliventres).
12. ,, PARASITICA.
13. ,, TUBULIFERA.
14. ,, ACULEATA.
15. COLEOPTERA.
16. LEPIDOPTERA.
17. DIPTERA. ORTHORHAPHA.
18. ,, CYCLORHAPHA.
19. SIPHONAPTERA.
20. RHYNCHOTA, HETEROPTERA

21. RHYNCHOTA, HOMOPTERA.
22. PHYTOPHTHIRES.
23. ANOPLEURA.
24. THYSANOPTERA.

It is, however, impossible to express accurately the relationship of insects by adopting any one sub-division of equal value throughout, and the student may be warned against getting to attach too much importance to any classification systems except as working conventions which have as much regard to truth as circumstances will allow.

What systems of classification we adopt is, in the present state of confusion, immaterial; the Fauna covers only parts of four orders and we can there adopt the system in use; beyond that we must unfortunately anticipate the "Fauna." The system adopted is the following; it is as near to Sharp's insects as possible, and we have contrasted it with the system in use in America as a guide to the student who wishes to refer also to American literature. We may remark that classification is not an end in itself but is the means to an end; with so vast and complex a subject, it is imperative that we should be able to classify, to fix the position of an insect with regard to its fellows, simply for ease of working. Our main object being the observation of living insects as they affect man, classificaton in this case becomes necessary to enable us to record and collate our observations; for this reason we aim at a simple system, on which we can arrange our collections, file our notes and, by working with one system, follow each other's work at once without having to readjust our ideas or bother more than is necessary with the way our things are arranged. The insects in one collection are arranged exactly as they are in another; a worker from a distance can take up work in Pusa without mastering a fresh system, and whether our classification be correct or not, it is, and must be, the standard and will be, we hope, with small modifications, the standard in India for many years.

NUMBER OF SPECIES.—Blanford in 1881 published a numerical enumeration of the known Fauna of India (J. A. S. B., p. 263). He includes Beluchistan, Kashmir, the Himalayas, Nepal, Sikkim, Bhutan, Assam, British Burma, Tennasserim, Ceylon, Andamans, Nicobars, which is practically the area now covered by the "Fauna of British India." We reproduce his figures :—

Orthoptera	350 (?)	1,700
Neuroptera	350	400
Hymenoptera	850	3,600
Coleoptera	4,780	6,000
Lepidoptera	4,620	10,000
Diptera	500 (?)	1,000
Rhynchota	650	3,000
TOTAL	12,100	29,700

giving also an enumeration of our own based on the available figures. Thus the Fauna of India and Hampson's later papers enumerate about 8,000 moths, there are about 1,500 butterflies, and we estimate 500 Tineids, etc. Mr. Distant has already enumerated 2,500 Rhynchota, and we anticipate 400 more with 100 Coccidæ.

Nomenclature.

Could we divide all known insects into, say, 300 families of roughly 1,000 species each, and group these systematically, our nomenclature would be a simple matter.

As we have explained above, the general object is to make *families* the basis of classification ; but we have in this volume to steer a middle course between the really accurate classification of the pure systematist, which changes as knowledge grows, and the practical point of view of those for whom we write ; we cannot keep remodelling our arrangement and nomenclature. *Odonata*, for instance, may be a sub-order composed of say seven families ; for us and for all field entomologists it is practically a family.

Whenever possible, family names end in—*idæ*, sub-family names in—*inæ*, and the names of tribes or sub-divisions of families in—*ini* ; the student must, however, remember that sub-family names frequently end in—*ides* ; and tribes in—*ines*. It is to be regretted that no uniform system can be introduced, and that were we to rigidly adhere to some system in this volume, the student would be puzzled when reading foreign text-books or literature.

IDENTIFICATION OF SPECIMENS.—Insects are known by names, nominally of Latin or Greek form, given to them by the entomologist who first describes them. That is, every distinct species of insect that has been described or accurately figured is designated by the specific name assigned to it by its first describer. The problem then is, with living or preserved insects on one side, and the mass of descriptions or figures on the other, to correlate the two.

Only working entomologists ever realise the immense labour involved in this work, except in the case of the fauna of a locality such as England where the insects have been studied very closely, where there are ample books, and reference collections. Where one has either a description of every species of insect of a country or a good reference collection, identification is a matter of so much comparison, but where as in India, the only handbooks contain descriptions only of part of the known insects, or where there are no handbooks at all, only scattered descriptions, and where there are no reference collections and access to the National Collections at the British Museum is impossible, the actual identification of an insect is not an easy matter and is not, as a rule, even possible in India. The question must remain so until there are complete handbooks such as the Fauna of India, which are kept up-to-date, and also complete reference collections of Indian insects, accurately named: progress to these is being slowly made, but very slowly indeed.

Actually if an insect belonging to one of the families described in the Fauna of India is sent in for identification, it is examined, referred to some division of its family, worked out with the generic key in the volume and compared with the descriptions in the volume ; if it exactly agrees with the description of a particular species, it is believed to be that species and is, if possible, compared with a specimen that has been identified by a specialist in that family. If it agrees with no species in the volume, it may be either a species described since the volume was prepared, or a species known from another country but not from India, or a new species ; to determine this requires an expert knowledge of the family, a complete literature of the family and a reference collection. On the other hand, if a beetle, for instance, is sent in, it is examined, referred to its family, and compared with any accurately named specimens of its kind which are available ; if it agrees with none of them it must be sent to a specialist in that family who has the literature, the reference collection, and, after years of work on that particular family, the requisite special knowledge. If proper attention was devoted to entomology in England, all specimens could be sent to the National Collection at the British Museum and there compared; at present this is not possible, and we are largely dependent on the kindness of workers in Europe and the United States.

It can be seen that the accurate identification of an insect is no easy matter in every case; in many cases it means months of waiting, and even years, as there are no workers for a large number of groups. As an accurate identification is necessary before publishing matter about any insect, this question is one of great importance; a large number of insects have been accurately identified and can be seen in the Pusa Collections; every assistance will be given in identifying insects, but the reader must realise what it means and be prepared to do the only thing he can to help, namely, to always send enough good specimens to allow of some being sent on to Europe, if the species is one that cannot be named from the Pusa Collection. This matter is discussed here because requests are constantly received for the name of an insect of which perhaps one mangled specimen is sent, and surprise is expressed because the identification is not immediately forthcoming. (See also Indian Insect Pests, page 57.)

ENTOMOLOGY IN INDIA.—This volume has been compiled primarily for the use of students of entomology in India and for those interested in the subject. A few words as to the present state of the subject in India will not be out of place.

Entomology, as a subject, occupies the whole time of one section of the Agricultural Research Institute, Pusa, and in this Institute alone there are three Entomologists with English University qualifications, and a staff of trained native workers. In connection with this Institute, there are a limited number of entomological assistants employed by the Agricultural Departments of each province for purely agricultural work and simple teaching. Whilst the ultimate object of work at Pusa is mainly agricultural and directed to useful practical ends, the work must rest on a scientific basis, and the collection, study, and classification of all insects of the agricultural areas of India is a necessary part of the activities of the staff. It is open to any worker in India to visit Pusa or to write there for advice or assistance, which will be freely given.

Our aim is to be in touch with every worker in India and to invite co-operation and mutual help. Elementary and advanced teaching in entomology is also given at Pusa and at no other place in India at the present time.

For many years, the Indian Museum, Calcutta, was the centre of entomological work, where a special staff was devoted to this subject, including the economic aspect. At the present time, the economic work has been transferred to Pusa, and systematic entomology takes its place as one branch of the systematic zoology which forms the work of one section of the Museum.

Collections of insects are preserved there, are constantly added to and are sent to specialists to Europe, just as the Pusa collections are. There is a large exhibit collection open to the public and the reference collections, while not open to the public, are generally available to workers in entomology.

Forest entomology is solely dealt with in the Forest Research Institute, Dehra Dun, by the Imperial Forest Zoologist and his staff, and all enquiries regarding insects injurious to forests are referred there. The study of insects injurious to tea is the work of the Entomologist to the Indian Tea Association stationed at Hilika, Assam.

Apart from minor and inconsiderable collections in Provincial Museums, the only other public collections exist at the rooms of the Bombay Natural History Society; members of this society refer specimens to the Committee who, if the Society's collection and library cannot furnish the required information, refer them to either of the above Indian Institutions or to Entomologists in Europe.

Excepting private workers who own private collections, there are no other centres of entomological activity in this country.

Publications dealing with entomology in its different aspects are issued as follows: The Imperial Agricultural Department issues, from Pusa, the "Agricultural Journal of India," in which are contained articles and notes relating solely to those insects injurious to crops or to those of economic value. Other and similar work is issued in bulletins; the more scientific or lengthy work is issued in memoirs and purely popular and useful information as leaflets.

The Imperial Forest Research Institute publishes information relative to Forest Entomology in "Forest Records and Memoirs," and some has appeared in the pages of the "Indian Forester." "The Bulletins of the Tea Association" contain the bulk of the work on insects injurious to tea, supplementary to the volume on Diseases and Pests of the Tea Plant by Watt and Mann. The Indian Museum, in "Indian Museum Records" and "Memoirs of the Indian Museum," issues articles mainly on systematic entomology but also bionomic work.

The "Journal of the Bombay Natural History Society" is the recognised medium for most purely systematic work and for some bionomic work; the papers in this Journal are of extreme value and must be consulted. We have referred below to the more important papers. The Journal of the Asiatic Society of Bengal contain also papers on general entomology and on systematic work.

This exhausts the present publications dealing with the various aspects of this subject in India; occasional papers on systematic entomology appear in the proceedings of learned Societies in England, Europe, the United States. A summary of these is contained in the Annual Report of the Board of Scientific Advice in India, as is a summary of all entomological work and publications in India.

It is necessary to mention one further publication no longer in existence. For over fifteen years, "Indian Museum Notes" was issued from the Indian Museum, Calcutta, and contained papers, notes, etc., dealing with economic and systematic entomology. We have made constant reference to it below and practically all information contained in it. dealing with the insects of the plains, is abstracted or referred to here. or is amplified in Indian Insect Pests. The best feature of this publication was its beautiful photogravure plates; the originals of many of these are here reproduced as text figures. Sets of this publication are still available at Pusa, and complete sets can be consulted in most official or public libraries in India.

With the exception of the Bombay and Asiatic Societies, the above publications are issued by Government and copies of most of them are available to serious workers. All can be seen also in most public libraries, and the published work in entomology is generally available. It is impossible to refer here to other literature; the reader will see below from how many sources we have drawn the published information of past years and these scattered papers are often very difficult to see. The best entomological libraries known to me in India are that of the Indian Museum, Calcutta, and of the Pusa Research Institute.

Of books dealing only with Indian Entomology, the Fauna of India is the only systematic one of real value now. It covers Aculeate Hymenoptera (2 vols.), a small part of Coleoptera (2 vols.), nearly the whole of Lepidoptera (6 vols.), Rhynchota to the end of Jassidæ (4 vols.). Progress with this is being steadily made and the student should ascertain what volumes have since been issued. They are the standard guides to the systematic entomology of India, Burmah and Ceylon and are essential in the arrangement and identification of species. Westwood's Cabinet of Oriental Entomology is with Donovan's "Insects of India," remarkable chiefly for beautiful plates in colour of many striking Indian insects, mainly butterflies, moths, large beetles and Fulgorids. It is the only book of its kind but is of little value at the present day except (in the words of Westwood), "that, by finding its way to the table of the Indian drawing room, it may gain additional converts to the study of a science full of curiosity and awaken an interest in the objects of pursuit, thus supplying an engaging occupation to our Indian friends."

A very short introduction to entomology is given in "Indian Insect Pests," which also treats of insects injurious to agriculture. It is the only general book on pure entomology relating solely to India published recently (1906), and contains short instructions regarding necessary apparatus, methods, etc. We assume every reader to have as much general knowledge as is included in the first part of that volume and in the second appendix.

ZOO-GEOGRAPHICAL DIVISIONS.—British India is not a distinct zoogeographical area, and it is necessary to define very carefully the faunal zone that is dealt with in this volume. The "Fauna of India" series deals with the Fauna of the Indian Empire and Ceylon, *i.e.*, Himalaya, Hindustan, Assam, Burmah, Ceylon, regardless of faunal zones, and we endeavour here to indicate the zoo-geographical status of this region.

In the first place, we wish to make clear that a fundamental point is elevation; starting from the plains of North India at an elevation of, say, 1,000 feet and going steadily up the Himalayas to say, 10,000 feet, one passes from, through and into three distinct life-zones, which we may call tropical, subtropical and temperate; the tropical extends to 2,000 feet elevation; it is marked by one period yearly of intense dry heat or a limited season of moist weather; the subtropical covers 2,000 feet to between 5,000 and 6,000 feet and is marked by a greater humidity, a more even and less intense temperature, a less limited period of rainfall; the temperate extends above about 6,000 feet. To accurately define the limits of the subtropical zone would require much elaborate detail; it commences for instance at an elevation of about 500 feet at the foot of the Eastern Himalayas, at about 2,000 feet at the foot of the Western Himalayas; in the Nilgiris it commences at about 2,500 feet on the Mysore plateau side but runs down to well under 1,000 feet on the Western Ghaut side; a large part of the Deccan above 1,000 feet is tropical; the Western Ghauts from 600 to 2,000 feet and over are subtropical, and in this case the dry tropical area (as at Poona and Nasik) is at a greater elevation than the moist subtropical belt. The zone is of course not definable merely on elevation; it is the moister more agreeable climate produced by the abundant rainfall falling on the slopes of moderate elevation which run up from the level plains to the Himalayas or to the various ranges of hills; it is a zone of varied vegetation, often forest or dense jungle; it is the zone in which tea, coffee, rubber, and similar crops are grown, and it is, in India, a belt along the hills, running up the valleys, as well as more or less isolated patches on the hill ranges of Central India, the Deccan and South India. The student can get some idea of it from the 2,000 feet elevation line on Eliott's meteorological atlas of India. The fauna of the subtropical zone is far more varied than that of the tropical zone or of the temperate zone and is quite distinct.

There are some prominent features of the tropical and subtropical faunæ which may be very briefly discussed here. We omit any discussion of the temperate fauna as, except in South India, it is certainly not "Indian" but is holarctic or Indo-Chinese. The subtropical fauna is far more varied than the tropical; the number of species that can find food and can support existence in the extremely varied vegetation and moist equable climate of the former is far greater than those that can endure the intense dry heat and more limited vegetation of the latter.

In addition to this, which is true of nearly every family of insects, there are families which are confined to the subtropical region, or which immensely predominate there as compared with these families in the plains, and there are also families which occur far more abundantly in the tropical plains. The *Phasmidæ, Siricidæ, Tenthredinidæ, Sialidæ, Panorpidæ, Passalidæ, Lucanidæ, Simuliidæ, Aradidæ, Phymatidæ, Sesiidæ, Zygænidæ* are practically confined to the moist forested lower hill slopes; the *Rhopalocera* are characteristic of the subtropical region, especially the *Nymphalidæ* and *Papilionidæ*; the *Cicadidæ, Tipulidæ, Mycetophilidæ, Locustidæ, Dynastidæ, Cetoniidæ, Erotylidæ, Endomychidæ, Bostrichidæ, Scolytidæ* are found abundantly in the subtropical, rarely in the tropical areas; *Chrysomelidæ, Buprestidæ, Capsidæ, Syrphidæ* occur in both but in immense profusion only in the former; *Limacodidæ* and *Phryganeidæ* stand out conspicuously in the same way. On the other hand, the *Acridiidæ, Carabidæ, Dytiscidæ, Hydrophilidæ, Gyrinidæ, Tenebrionidæ, Myrmeleoninæ, Ascalaphinæ, Scarabæidæ* are far more abundant in the plains, though occurring also in the lower hills. Allowing for the fundamental excess of species in the subtropical region owing to its varied flora, the other large families are more proportionately represented in both areas. We would suggest also that the varied surface fauna of the plains is less marked a feature of the subtropical region, possibly because the surface soil offers protection from heat not required in the hills and because the usually dense perpetual vegetation of the hills produces a fauna centering more round the bushes and low vegetation (see below " Where Insects Live " under *Forficulidæ*).

This fundamental distinction is of the very greatest importance, and unless it is fully realised and clearly kept in mind, any conception of the faunal zones must be imperfect. We sharply mark off the fauna of the plains of India (usually below 2,000 feet) from that of the forested slopes of the hills and from that of the upper hills; and, in this volume, we deal only with the tropical zone except where the number of species occurring in India is stated when we mean British India exclusive of the temperate upper Himalayas.

India is placed by Beddard (Zoogeography 1895) in the Oriental Region as the " Indian " subregion; Ceylon is distinct as a subregion and is taken to include part of South India. The Himalayas, inclusive of Kashmir, Nepal, Sikkim, Bhutan, are not part of the Indian subregion at all, being holarctic, and we take the dividing line to be at about 6,000 feet. The extreme North-West of India is also not strictly "Indian" but is holarctic. Burmah, we exclude, as being Malayan and Indo-Chinese, and the hills of Assam are strictly Indo-Chinese in part. "India" proper then does not include these areas at all and it must be clearly borne in mind that in these pages we do not use India in the sense that the "Fauna of India" does; the term "British India" is used throughout this volume for the political India covered by the Fauna; the term "India" includes tropical and subtropical India, *i.e.*, up to about 6,000 feet; "subtropical India" denotes the moist forested slopes of the hills usually between 2,000 and 6.000 feet; "tropical India" or "the plains" means the great stretches of India lying between sea-level and about 2,000 feet, usually not forested and extending from Tinnevelly in the South to Rawal Pindi in the North, from the border of Sind and Baluchistan in the West to the Assam and Surma valleys in the East. It is the insects of this area that are discussed in these pages and for one insect in this area there are at least five in "subtropical India."

The frontispiece illustrates the divisions of tropical India according to fauna so far as we are able to tentatively delimit them; the faunal zones of subtropical India are not indicated. In considering this question fully, the factors to be considered are (1) the physical features of the country; (2) the geological formation composing it; (3) its climate; and (4) its flora. The first three probably affect insects in much the same way as they affect plants, and we may take the flora as the basis of our divisions; Sir J. D. Hooker, in his sketch of the flora of British India, divides the whole area into nine provinces as follows :—

(1) *Eastern Himalayas.*—Sikkim to Mishmi mountains in Upper Assam.

(2) *Western Himalayas.*—Kumaun to Chitral.

(3) *Indus Plain.*—Punjab, Sind, Rajputana, west of the Aravalli range and the Jumna river, Cutch and Gujarat (to the Tapti).

(4) *Gangetic Plain.*—From the Aravalli Hills and the Jumna river to Bengal, the Sundarbans, the plains of Assam, the low country of Orissa north of the Mahanadi.

There are three distinct sub-provinces; the dry upper area, the United Provinces and Behar; the lower humid area, the Assam plain, Lower Bengal and Orissa; and the Sundarbans.

(5) *Malabar.*—The Western Ghauts from the Tapti river to Cape Comorin; the Konkan, Kanara, Malabar, Cochin, Travancore, Laccadive Islands. This is better termed the West Coast.

(6) *The Deccan.*—The high plateau lying between the Eastern and Western Ghauts, south of the Gangetic and Indus plains; the Coromandel Coast on the East Coast from the Mahanadi to Cape Comorin is included as a sub-province.

(7) *Ceylon and the Maldive Islands.*

(8) *Burmah.*

(9) *The Malay Peninsula.*

With the last three, as with the first two, we have no concern here. If on the basis of the above divisions we omit subtropical forest hill areas, and we take into account the influences on the fauna of these neighbouring areas, we shall get divisions as follows:—

1. The Indus Plain.
2. Desert India.
3. Central India, West.
4. Gangetic Plain, West.
5. Gangetic Plain, East.
6. Sundarbans.
7. Central India, East.
8. Deccan.
9. West Coast.
10. Coromandel Coast.

1. *The Indus Plain* has a fauna containing many holarctic forms. The winter is cold, the hot weather is dry and intense and these two seasons are well marked.

2. *Desert India* is similar, but with a peculiar fauna and flora, owing to the arid conditions.

3. *Central India, West.*—An area of greater rainfall, a more definite period of humidity and less alternation of day and night temperature.

4. *Gangetic Plain, West.*—Well marked winter with moderate cold and rain, dry hot weather and moist rainy weather. Immigrants from the Himalayas for the cold weather.

5. *Gangetic Plain, East.*—No well-marked dry hot weather, the humidity higher in the cold weather and hot weather. Immigrants from the Himalayas and other hills for the cold weather and insect activity more general in the hot weather; there is a marked Malayan element. (A feature of this area is the flooding that occurs over large stretches of land; the influence this exerts on the fauna may be a very marked one.)

6. *Sundarbans.*—Doubtfully distinct. Little alternation of temperature or humidity. Peculiar flora. Strong Malayan element.

7. *Central India, East.*—Well-marked dry hot weather when insect activity is suspended, followed by a prolonged moist warm period. Fewer insects hibernate than in the regions North and West.

8. *Deccan.*—Well-marked seasons, the dry hot weather following a marked cold weather, when hibernation sets in.

9. *West Coast.*—The fauna is influenced by the neighbouring subtropical region of permanent forests and high humidity which produce a very large fauna equalled only by the lower slopes of the hills in Assam and the Eastern Himalayas. No hibernation in the plains below ghauts. Many Ceylonese forms.

10. *Coromandel Coast.*—Less well marked seasons to the Deccan, and a smaller flora to the West Coast. A large proportion of Ceylonese forms.

We may roughly indicate the separate faunal zones into which we would divide British India as a whole exclusive of Burmah and Ceylon:—

1. ***Indus Plain.***—Tropical.

2. ***Himalaya, West.***—Western Himalayas above 6,000 feet, including Kashmir, Nepal and Kumaon. Holarctic.

3. ***Sub-Himalaya, West.***—Lower slopes of Western Himalayas 2,000 to 6,000 feet. Subtropical forest fauna.

4. ***Desert India.***—Tropical.

5. ***Central India, West.***—Tropical.

6. *Central India, West, Hills.*—Subtropical.

7. *Gangetic Plain, West.*—Tropical.

8. *Gangetic Plain, East.*—Tropical.

9. *Sub-Himalaya, East.*—Lower slopes of Eastern Himalayas 700 to 5,000 feet. Subtropical.

10. *Himalaya, East.*—Eastern Himalayas above 5,000 feet. Sikkim to Mishmi Mountains. Holarctic.

11. *Assamia.*—Hills of Assam and Assam-Burmah border, inclusive of Khasi hills, above 6,000 feet. Indo-Chinese.

12. *Sub-Assamia.*—Lower slopes of Assam hills, 500 to 5,000 feet. Subtropical with strong Malayan affinities.

13. *Sundarbans.*—Tropical.

14. *Central India, East, Hills* above 500 to 800 feet. Subtropical.

15. *Central India, East, Plains.*—Tropical.

16. *Deccan.*—Tropical.

17. *West Coast, Plains.*—Tropical.

18. *Western Ghauts.*—Hills up to 6,000 feet. Subtropical. This is probably divisible into three; (*a*) Surat to Londa-Goa gap; (*b*) Goa gap to Palghat gap with the Nilgiris, Coorg, Mysore Hills; (*c*) South of Palghat gap, including Travancore, Pulneys, etc.

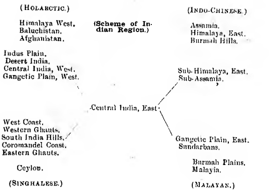
19. *South India Hills.*—Hills of West Coast and South India above 6,000 feet. The fauna of this zone is not sufficiently known, as apart from the fauna below 6,000 feet, for this division to be more than a doubtful one.

20. *Coromandel Coast.*—Tropical.

21. *Eastern Ghauts.*—Subtropical.

Classing these zones under elevation and climate we get:—

Temperate.	Subtropical.	Tropical.
Himalaya, West ..	Sub-Himalaya, West ...	Indus Plain.
		Desert India.
	Central India, West, Hills	Central India, West.
.. East ..	Sub-Himalaya, East ...	Gangetic Plain, West.
Assamia	Sub-Assamia ...	,, ,, East.
		Sundarbans.
	Central India East, Hills ..	Central India, East.
	Western Ghauts	Deccan.
		West Coast.
South India Hills ..	Eastern Ghauts ...	Coromandel Coast.



FOOD AND HABITAT.

Insects live in a great diversity of ways, but it is possible to roughly classify these into groups; this classification is of considerable value to the student in placing his insect; for instance, a tree-boring insect will be a member of one of a small number of families, and it will often assist in placing an insect to look up the families which have a particular habit *i.e.*, it is useful to classify insects according to food and habitat, as well as by structure and genealogy. For this purpose we tabulate below the principal families that live in distinct ways, using food and habitat together as the basis of our classification.

I.—LAND INSECTS. A. HERBIVOROUS.
1. LIVE IN FRUITS.
2. ,, ON SEEDS.
3. ,, ,, FLOWERS.
4. LEAF AND STEM MINERS.
5. LEAF AND STEM SUCKERS.
6. LEAF AND STEM EATERS.
7. GALL MAKERS.
8. TREE BORERS.
9. STEM BORERS.
10. ROOT EATERS.
11. ROOT BORERS.
12. ROOT SUCKERS.

- I.—LAND INSECTS —*contd.*
  - B. Parasites and Predators.
    - 13. Parasites, Internal of Vertebrates.
    - 14. Parasites, External of Vertebrates.
    - 15. Parasites, Internal of Insects.
    - 16. Predators, Stinging.
    - 17. Predators, Biting and Sucking.
  - C. Scavengers.
    - 18. Scavengers, Animal Matter.
    - 19. Scavengers, Dead Wood.
    - 20. Scavengers, Vegetable Matter.
    - 21. Household Insects.
- II.—SALT WATER INSECTS.
- III.—FRESH WATER INSECTS.
- IV.—MYRMECOPHILOUS INSECTS.

1. Fruit Insects.—The *Trypetidæ* are conspicuous, as are such Tortricids as the Codlin Moth (*Carpocapsa*) and *Tineidæ*. Noctuids and Curculionids are found. In all cases it is the larvæ that live thus; *Tenthredinidæ* are rarely known. Some large moths (*Ophideres*) live on fruit juice. We exclude all "Scavengers" in decaying fruits, of course, referring only to fruits on plants.

2. Seed Eating Insects.—Many insects feed habitually on seeds while ripening; *Bruchidæ*, *Scolytidæ*, *Tortricidæ*, *Tineidæ*, *Pterophoridæ* (*Exelastis*, *Sphenarches*), *Noctuidæ* (*Chloridea*, *Earias*), *Pyralidæ* being typical examples; the Lycænid (*Virachola isocrates*) is an exceptional case. We omit all insects living on harvested seeds, classing them as Scavengers or household insects.

3. Flower Insects.—*Forficulidæ* eat pollen, *Masaridæ* and *Apidæ* collect pollen. *Fossores* collect pollen, or feed on nectar. *Phalacridæ* (larvæ), *Nitidulidæ* (larvæ and adults), *Melyridæ* (adults), *Lampyridæ* (adults), *Mordellidæ* (adults), *Curculionidæ* (adults), *Melolonthidæ* (adults), *Cantharidæ* (adults) feed on pollen or flowers. Most moths and butterflies and many flies, especially *Anthomyiidæ*, *Syrphidæ* and *Bombyliidæ*, feed on nectar. *Tineidæ*, *Pterophoridæ*, *Cecidomyiidæ*, *Thysanoptera*, *Tingidæ* also live in flowers, as larvæ or nymphs.

4. **Leaf and Stem Miners.**—The Hispids and Halticids among Chrysomelids, and many Tineids mine under the epidermis of green leaves and green stems. Exceptional Micropterygids, Buprestids (*Trachys*), and Acalyptrate Muscids are also recorded.

5. **Leaf and Stem Suckers.**—The *Thysanoptera*, the whole of the *Homoptera* and *Phytophthires*, as well as most of the species of the following families of Hemiptera live by sucking the sap of green parts of plants :—*Pentatomidæ, Coreidæ, Berytidæ, Lygæidæ, Pyrrhocoridæ, Tingidæ, Capsidæ.*

6. **Leaf Eating Insects.**—All *Phasmidæ* and *Acridiidæ*, most *Locustidæ*, some *Gryllidæ* feed on leaves, as too do the larvæ of *Tenthredinidæ*, Melolonthid beetles, a few exceptional Carabids and Silphids, Epilachnids in both stages, Cantharid beetles, Chrysomelids in both stages, and Curculionids (rarely in the larval, almost always in the imaginal stage) have the same habit. The larvæ of *Lepidoptera* in most cases are purely leaf eating.

7. **Gall Insects.**—In India, the known gall insects are typically Psyllids, Tineids, Chalcids (fig insects) and Cecidomyiids, the first predominating. Other families recorded elsewhere are *Tenthredinidæ (Nematus), Cynipidæ, Buprestidæ (Ethon), Curculionidæ, Thysanoptera, Aphidæ and Coccidæ.*

8. **Tree-Boring Insects.**—The following families make tunnels in trees ; *Siricidæ, Buprestidæ, Cerambycidæ, Curculionidæ, Scolytidæ,* (? Brenthidæ), *Sesiidæ, Cossidæ, Hepialidæ, Arbelidæ.*

9. **Stem Borers.**—A large number of borers live in green succulent stems as opposed to those living in hard woody tissues. The families concerned are, *Gryllidæ (Cylindrodes), Cephidæ, Tenthredinidæ, Phalacridæ, Erotylidæ, Buprestidæ, Mordellidæ, Curculionidæ, Scolytidæ, (Castniidæ), Noctuidæ, Pyralidæ, Cecidomyiidæ, Chloropidæ, Agromyzidæ, Geomyzidæ, Ortalidæ.*

10. **Root Eating Insects.**—Very little is known of the lives of underground insects, but the following groups contain species that feed on plant roots in the soil.

Melolonthid larvæ.
Elaterid „

Curculionid larvæ.
Pyralid ,, (*Crambidæ*, etc.).
Noctuid ,, (rarely).
Gryllid nymphs and adults.
Tipulid larvæ.

A few of the *Silphidæ* (*Anisotomides*), *Dascillidæ* and *Bibionidæ* (*Dilophus*), have apparently the same habit.

11. Root Borers.—The *Hepialids* are conspicuous as root borers; the *Sagridæ* are said to have this habit as have some *Eumolpids* (*Scelodonta*) and *Galerucids* (*Diabrotica*, probably *Aulacophora*); some *Pyralids* have it, *e.g.*, *Schœnobiinæ*: exceptional *Buprestidæ* (*Sphenoptera*) and *Curculionidæ* (*Cylas*) are also known.

12 Root Sucking Insects.—Just as there are insects which suck plant tissues above ground, so others do below ground, but we know little of them. Probably a considerable number of species in the following families are concerned: *Pentatomidæ*, *Lygæidæ*, *Cicadidæ*, *Fulgoridæ*. *Aphidæ*, *Coccidæ*. In most cases it is probably the immature stages that have this habit. The best known example is the *Phylloxera* of the vine.

13. Internal Parasites of Vertebrates.—The *Oestridæ* are the important group in which this habit is universal; the Muscids that cause Myiasis may perhaps be included. We omit the many recorded cases of insects bred in the human alimentary canal as being exceptional.

14. External Parasites of Vertebrates.—So much is written of these we need only tabulate the families: *Hemimeridæ* (on rats), *Mallophaga*, *Platypsyllidæ* (on beavers), *Hippoboscidæ*, *Streblidæ*, *Nycteribiidæ*, *Aphaniptera*, *Polyctenidæ*, *Cimicidæ*, *Anoplura*. We omit the non-parasitic biting flies.

15. Parasites of Insects.—The *Parasitica* among the Petiolate Hymenoptera, the *Chrysididæ*, the parasitic *Apidæ*, and the *Tachinidæ* are the common parasitic insects. Other groups are the *Mantispides* (on spiders eggs), the *Mordellids* (*Emmenadia*, etc.) (the Clerides), the *Cantharidæ* and *Stylopidæ*. Of Diptera, little is known, but we may mention *Nemestrinidæ*, *Bombyliidæ*, *Pipunculidæ*, *Cyrtidæ*, *Conopidæ*, *Anthomyidæ*, *Tachinidæ*, *Sarcophagidæ*, *Muscidæ*, *Braulidæ* (external).

16. **Predators, Stinging.**—A peculiar class are those insects which sting insects to paralyse them and lay them up for their young; they include only *Eumenidæ*, *Pompilidæ*, *Sphegidæ*, *Scoliidæ*.

17. **Predators, Biting and Sucking.**—It is impossible to indicate with any accuracy the families containing predaceous insects; probably a very large number of insects living in soil and under bark are,predaceous, notably beetles and smaller bugs. We tabulate a number of families with remarks.

Forficulidæ ; ?
Mantidæ ; all.
Locustidæ ; some.
Gryllidæ ; some, *e.g.*, *Schizodactylus*.
Odonata ; larvæ and imagines.
Raphidiides ; imagines.
Panorpides ; imagines.
Myrmeleonides ; larvæ all ; imagines ?
Ascalaphides ; ,, ,, ,,
Mantispides ; some.
Hemerobiides ; larvæ.
Chrysopides ; larvæ ? imagines.
Coniopterygides ; larvæ.
Eumenidæ ; the wasps eat insects.
Vespidæ ; ,, ,, ,, ,,
Cicindelidæ ; all.
Carabidæ ; practically all.
Silphidæ ?
Staphylinidæ ; probably all.
Histeridæ ; some, under bark.
Trogositidæ ; some.
Colydiidæ ; some.
Cucujidæ. ,,
Coccinellidæ ; nearly all.
Malacodermidæ ; larvæ all ; imagines ?
Cleridæ ; all.
Anthribidæ ; some.
Brenthidæ ; imagines, larvæ ?
Lycaenidæ. (*Spalgis*).
Noctuidæ ;
Phycitinæ ; } A few species feed on Coccids.
Tineidæ. (*Hypatima*).
Some Culicid larvæ.
Blepharocerids ?
Therevids ; fly and larvæ.
Muscids (Ochromyia).
Some Anthomyiids & Ephydrids.
Some Scatomyzids.
Leptidæ ; larvæ and flies.
Tabanidæ ; ,,
Asilidæ ; all.
Empidæ.
Dolichopidæ.
Phoridæ ; larvæ.
Syrphidæ ; ,,
Bombyliidæ ?
Pentatomidæ ; some.
Lygæidæ ? many.
Aradidæ ?
Henicocephalidæ.
Reduviidæ.
Phymatidæ.
Saldidæ.

18. SCAVENGERS OF ANIMAL MATTER.—There is a very large class of insects that live upon refuse animal or vegetable matter as apart from those feeding on live plant tissue or on the blood or tissues of animal life. Of this class, a portion feed in dung, corpses, etc. The family *Scarabæidæ* are a notable example of the dung feeders, the *Sarcophagidæ* notable as breeding in corpses, the *Formicidæ* notable as carrying off dead insects. Other families are *Blattidæ, Silphidæ, Staphylinidæ, Histeridæ, Nitidulidæ* (?) *Cleridæ, Mycetophilidæ, Rhyphidæ,* several *Muscidæ Acalyptratæ* (*Borboridæ, Sepsidæ*) and many *Calyptratæ*, (?) *Phoridæ.*

19. SCAVENGERS OF WOOD.—The insects that feed in dry or decaying wood are a distinct class, but it is difficult in some cases to distinguish them from the insects that prey on them. The following nine families are well known: *Termitidæ, Bostrichidæ, Ptinidæ* (*Anobiides*), *Lymexylonidæ, Oedemeridæ, Cerambycidæ, Anthribidæ, Scolytidæ.* Occasional Tenebrionids and Tineids may be added.

20. SCAVENGERS OF VEGETABLE MATTER.—This is perhaps our largest individual class since we have not the data on which to break it up into such groups as in the case of Herbivores. It is of extreme importance in the daily routine of agricultural entomology to be able to distinguish the harmless insect eating dry dead leaves from the injurious one eating living parts of the plant. We can here only enumerate the more important families or those in which the habit is known, with the remark that fungi are included as food of this class as well as decaying leaves, fruits, blossoms and other soft parts of plants.

Aptera.
Blattidæ.
Embiidæ.
Psocidæ (? feeding on living fungi).
Passalidæ (larvæ).
Lucanidæ (larvæ).
Melolonthidæ (larvæ).
Scaphidiidæ (fungi).
Histeridæ ?
Nitidulidæ.
Trogositidæ (*Peltides* on fungi).
Colydiidæ.
Cryptophagidæ.
Erotylidæ (? fungi).
Endomychidæ (? fungi).
Mycetæidæ (fungi).
Latridiidæ (fungi).
Byrrhidæ (plant sap).
Cioidæ (fungi).
Sphindidæ (fungi).
Dascillidæ (*Eucinetus* on fungi).
Elateridæ (? larvæ).
Nilionidæ (fungi).
Melandryidæ.

Anthicidæ.
Calandrinæ.
Mycetophilidæ (fungi).
Chironomidæ.
Psychodidæ.
Tipulidæ.
Bibionidæ.
Rhyphidæ.
Lonchopteridæ.
Syrphidæ.
Phoridæ (larvæ).
Trypetidæ.
Sapromyzidæ.
Anthomyidæ (larvæ).
Thysanoptera ?
Aradidæ (? fungi).

21. HOUSEHOLD INSECTS.—We cannot separate this class of insect clearly from the last or from some others logically, because our household insects are simply originally free-living ones that have found a living in man's dwellings. Nor can we make a separate division of them on the same scale as the Myrmecophilous insects, as we should perhaps logically do. The student will find further information under the heading Cosmopolitan insects below. The families concerned are :—

Thysanura.
Blattidæ.
Gryllidæ.
Psocidæ.
Termitidæ.
(*Nemopterides*)
Formicidæ.
Silphidæ.
Trogositidæ.
Cucujidæ.
Nitidulidæ.
Ptinidæ.
Bostrichidæ.
Bruchidæ.
Cerambycidæ.
Pyralidæ (*Galleriinæ*, *Phycitinæ*).
Tineidæ.

We have excluded external parasites of mammals, though they may rightly be included here, since they are classed as above.

II. MARINE INSECTS.—Very few insects live in, on, or within reach of salt water, probably on account of the difficulties of respiration due to the deposition of salts on evaporation of the water.

Anurida among *Aptera*, *Æpophilus* among *Coleoptera*, *Campontia* among *Chironomidæ*, *Eristalis* and some allies among *Syrphidæ* live in sea water, *Halobata*, a genus of *Hydrometridæ* lives on the sea. Some *Forficulidæ*, *Carabidæ*, *Cicindelidæ*, *Staphylinidæ*, and *Muscidæ* live in sea-weed on the beach.

III. FRESHWATER INSECTS.—The student will find fuller information under the heading Aquatic insects after the family *Odonata* below.

We give here simply a bald list of families, but we make no attempt to class them into Herbivores, Parasites, Predators, and Scavengers as could well be done :—

Collembola.
(*Blattidæ*).
Ephemeridæ.
Odonata.
Perlidæ.
Sialidæ
(*Hemerobiidæ*).
Trichoptera.
(*Chalcidæ*).
Amphizoidæ.
Pelobiidæ.
Haliplidæ.
Dytiscidæ.
Gyrinidæ.
Hydrophilidæ.
Heteroceridæ.
Parnidæ.
Dascillidæ.
Chrysomelidæ.
(*Curculionidæ*).
(*Eupterotidæ*).
(*Pyralidæ*).
Culicidæ.
Chironomidæ.
Psychodidæ.
Dixidæ.
Tipulidæ.
Blepharoceridæ.
Simuliidæ.
Stratiomyidæ.
Tabanidæ.
(*Syrphidæ*).
(*Acalyptrate Muscids*).
Hydrometridæ.
Pelogonidæ.
Nepidæ.
Naucoridæ.
Belostomidæ.
Notonectidæ.
Corixidæ.
(*Aphidæ*).

IV. MYRMECOPHILOUS.—The student will find fuller information regarding Myrmecophilous insects under *Paussidæ*. The more important families of which species are found in ant's and termite's nests are :—

Gryllidæ.
Melolonthidæ.
Paussidæ.
Silphidæ.
Gnostidæ.
Pselaphidæ.
Staphylinidæ.
Histeridæ.
Thorictidæ.
Cossyphodidæ.
Syrphidæ.
Psyllidæ.
Aphidæ.
Coccidæ.

INSECTS AND MAN.—With the exception of domestic animals there is no single group of animal life which enters more into the daily life of man than insects. They live on us and around us; in our food, our clothes, our furniture, our houses; we eat them or their products, we collect them and even sew them on our clothing. All people eat honey, use bees-wax, clothe themselves in silk, and there is no one who has not, at one time or another, been dependent upon some member of the insect world. The luxury of the present age of civilised peoples has brought into being industries connected solely with the collection of the more beautiful and striking forms, which are worked up into wall ornaments, paper weights, etc., and form a part of the art of this age. (Witness the advertisement in the Studio "Artistic Cases of Tropical Butterflies, exquisite colours and designs, supplied to many Art Schools, etc.") Man is, therefore, dependent on the insect world for so much, and though science may devise substitutes for the products derived from insects, some of them at least will never replace the genuine thing. No artificial honey will ever compare with the honey gathered by bees from thousands of flowers, fragrant of thyme or heather or logwood, though in this commercial age, chemically-prepared substitutes, composed of glucose and coal tar flavourings, are sold and accepted as genuine; no substitute for bees-wax has been found, nor for shellac. It is likely that silk, as a commercial article among commercial nations, will be partly replaced by artificial substitutes, because the greatest value of true silk—durability—is of no value to an advanced civilisation which does not require to be clothed but costumed. Lac dye has been replaced by aniline, and though cochineal still holds its own for food colouring to some extent, it is probable that no insect-made dye will continue to hold its own against aniline dyes.

These are the useful insects; there are many that affect man in other ways. Why is it that almost every dry form of food sold and dealt in by commerce must be placed in a sealed package? Why are millions of tins used yearly in a single city? Why do we pay at least a fourth again of the value of biscuits, simply because of the tin? Very largely because of the ubiquitous insect, who would get in and eat them, if these things were not thus protected. Let any house-keeper in India think for a moment of her store-room and the precautions she takes. Sugar must be isolated or ants will carry it off; flour must be in a tightly-closed tin, or moth, weevil or beetle gets in; no sweet thing is safe, once opened, unless isolated on water, dried fruits of every kind are spoilt by beetles, grain is eaten by weevils; pulse of all kinds harbours moths or beetles; even tobacco and dried drugs are not exempt. Daily and hourly mankind is fighting the ravages of the insect world, which seeks to take from him his last ultimate asset, his stock of food. Think of the countless sealed and grain-stores there are in India, many in every village, and all because of the insect life around us.

Let us take another aspect, that of disease; malaria, enteric, typhoid, yellow fever, plague, filariasis and elephantiasis, sleeping sickness (? kala azar, black water fever), each and every one of these means a yearly total of deaths, premature and unnecessary, caused by the agency of insects. Think of the enormous total of deaths from plague in India, since plague came into India little more than a decade ago; think of the desolation caused by sleeping sickness in Africa, of the countless cases of malaria in the tropics, of the extraordinary mortality from yellow fever, in old days, in the West Indies; go to the West Indies and see the numerous cases of elephantiasis; men with legs like trees, men suffering from fever and ague for years which finally leaves them possessed of an elephant's leg or arm; think of the death-roll from enteric! And after all this we may dimly realise the important part the insignificant insect world around us plays in our lives.

This may be equalled by that part played by insects in inducing disease among our domestic animals. This is a purely artificial case largely brought about both by our careless transfer of stock from one part of the world to another and by our own reckless disregard of the rudiments of science and of all reasonable precautions. Think again of the agriculturist and his foes; of the locusts which lay waste a district, of the bollworm that takes a tenth of the cotton-crop in India, or perhaps three-quarters of it in an occasional year; of the mothborer that kills one cane-shoot in three; of the rice hispa that causes famine or the rice grasshopper that destroys the paddy over a whole division; think of the trials of new and promising crops abandoned in the past, because insects ruined every plant on a small plot. Why does not tree cotton grow successfully in India, or improved American maize; why has no fruit industry been established in places where fruit grows; why is shade-grown tobacco not a success, or the cultivation of sunflower or ground-nuts in North India? What takes toll of every crop grown in this country to a greater or lesser extent? Insects in every case insects; and insects are a factor to be taken into account in agriculture all the world over.

Think of one's daily life! There are cockroaches that smell, fish insects that eat our papers, ants that carry off our sugar, "gundies" and other smelly things that flavour our food when they fall in, wasps and hornets that sting, mosquitoes that bite and annoy, to say nothing of sand-flies, that no mosquito net keeps out, and the bug and flea which continually pester us, the mud wasps that build nests in our books and close our locks; furniture beetles that wear out our chairs, the cheroot beetles that spoil our cigars, the book beetle that tunnels in our books, the moth that destroys our clothes. Daily and hourly we come in direct contact with insect life. Read the doleful comments of the Calcutta resident in August, asking why science cannot check the insects that come to his lamp during dinner and make his life a burden: or the sad tale of the District Officer who had to vacate his bungalow because the wasps wanted it and had been accustomed to have it: or again the tale of the telegraph stores which were hurriedly wanted in large quantities, but could not be touched because hornets had built nests among them and actively resented any interference; or that of the greatcoats ready to be distributed to the army, each being found with neat little holes eaten out by beetles. Impartial judgment and a dispassionate consideration of facts will show that insects have fully exploited man, and, that though man may think that he is dominant, he really is not, and that not the least among his functions is that of providing food and occupation for insects.

It has been the custom of authors of all periods to refer all insects in some way to man's well-being and economy. Every insect was, to them, created with some definite object from man's point of view: and one has only to accompany a party of visitors round a collection, even in this twentieth century, to find this view still expressed. "What is the use of this?" "Why was that created?" Man may or may not be the central being of this earth, but to attempt to refer the activities of all insects in some way to his welfare is, at least, a problem that none would attempt. An American author says : " fleas are good for a dog, because they keep him from brooding over being a dog," and explanations of this kind are possible where our domestic insects are concerned. But, were insects given to that kind of mentality and speculation (as they may be), it would be interesting to get their views on man and his place in their nature. Assuredly it would not agree with ours ; equally it may be, that, from any standpoint, whether material, mental, moral or spiritual, man is on no higher a level than insects ; and it might be better to classify our activities as they affected insects than to refer each insect to its " use " to us.

A rough classification of the ways in which insects affect man may be attempted, chiefly with a view to securing clearness of idea :—

1. Cause damage to growing plants directly.
2. ,, ,, ,, ,, ,, indirectly.
3. ,, ,, ,, stored products.
4. ,, ,, ,, domestic animals directly.
5. ,, ,, ,, ,, ,, indirectly.
6. Personally distasteful.
7. Transmit disease to man.
8. Assist agriculture directly.
9. ,, ,, indirectly.
10. Yield useful products.

It is needless to dilate upon the first class ; all the insects that feed upon, or live in growing plants that are useful to man, are included. Of the second, we would say that very little is known, but that there may be a very large class whose quite unimportant attacks on plants open the way to the entry of fungoid or bacterial diseases, which may then become of great importance. There is a great difference between the small damage caused by the cane-borer direct and that of the fungus it brings or lets in ; and the broader aspects of this question are as yet but little known. The insects injurious to stored products, to grain, flour, dry food-products of all kinds, to timber, furniture, books, paper, fabrics, to every kind of human merchandise, made of material of animal or vegetable origin, these are only too painfully familiar to us all, and, in the genial warmth and moistness of the Indian climate, they find conditions admirably suited to their plentiful increase. Insects that directly injure domestic animals include lice, ticks, fleas, horse-flies, bots, warbles and other parasites of cattle, horses, sheep, dogs, etc. Under the head of indirect injury is the transmission of disease, of which flies and probably lice, fleas and horse-flies may be especially important.

Of those personally distasteful, it is hard to speak. The mosquito that bites and sings, the cockroach that flies around before rain, the eye-fly that thinks its proper sphere is man's visual organ, the crawling caterpillar that falls from on high, each (and many more) is distasteful in some degree to different individuals. The dweller in Bengal is harried by hordes of perfectly amiable and delightful insects which join him when the lamps are lit. As I write, they swarm around me, in great variety, in pleasing profusion, adding, by their mere number and senseless gyrations, to the irritation caused by climate, weariness, liver, etc. In some places "gundies" (*Cydninæ*) are pre-eminent, in other places green fly (*Jassids*); the geranium (*Cydnus*) is familiar to some, while our curse here is varied but largely composed of beetles (*Scaritids* chiefly). Whatever they are, their profusion, their ubiquitousness, their buzzings and their singed or oily corpses cause an annoyance only to be appreciated by experience, and which forms not the least of the ills we bear.

Elsewhere the reader will find an account of the insects transmitting human disease, the go-betweens, which add so enormously to the death-roll, which cripple so many lives and which constitute the first and greatest menace to human life in tropical countries.

So far all is ill and were we to consider this only, then insects would have but a sinister significance. There is another side and still taking our anthropocentric view, we may consider the classes of insects on which man's welfare depends. A very large class of insects promote tillage, by burrowing and excavating in the soil; they sweeten the soil and render the growth of plants possible. This is especially the case in tropical India, where worms are not so abundant; it is impossible to bring accurate proof of this, but it is easy to observe the countless borings of insects in undisturbed soil, especially under trees and where there has been no cultivation. In addition to this, insects do much directly to enrich the soil by carrying down dung, by burying carcasses, by causing the decay of fallen vegetable matter. It requires but little observation and thought to see how large a part insects play in this, and how greatly they assist in keeping the earth sweet and wholesome, and in rapidly restoring to the soil available food; with the bacteria, the fungi and similar organisms, they play a great part in the constant cycle of matter through the soil to some form of life and back to the soil again. In these ways insects assist agriculture directly. Another great function they exercise is in pollination; a large proportion of plants are dependent upon insects for their fertilisation and we largely owe the beauty of many flower forms of the plant world to the need the plant has of attracting the insect and of inducing it to carry the pollen. The significance of insects in this respect requires no proof; one can observe it both in the plants themselves and in their numerous insect visitors.

Indirectly insects are also a benefit as they check themselves and also help to keep down the undue prominence of weeds and particular forms of plant life. It is perhaps a paradox to ascribe as a virtue to insects the fact that they check themselves, because, if they did not exist, no check would be needed; still it is a sober fact that parasitic insects are an important part of the insect world, and if they were absent for a few weeks, India would starve. Finally, there are the useful insects. These are connected with :—(*a*) silk, (*b*) lac, (*c*) wax, (*d*) dyes, (*e*) medicine, (*f*) food for man, (*g*) food for domestic animals, (*h*) ornament.

Those that yield silk are perhaps pre-eminent at present since important industries are dependent upon the silk excreted by the pupating caterpillar of one of four moths. The value of the exported silk in 1906-7 was 204 lakhs, but much more was produced and used in the country itself.

Lac is a large industry, one of the big staples of India, and, since its use is yearly growing and the source of supply is limited, it is an industry that brings increasing wealth to this country. The export in 1904-5 was valued at Rs. 3,47,00,000 and, besides that, a large amount was used in India.

Wax is still an article of export, fetching a high price and we may see established in the future a large industry in the domesticated bee, for the production of both wax and honey. The yearly export for the last twenty years has fluctuated between 3,000 cwt. and 7,000 cwt.: the value being between 2¾ and 7 lakhs.

The importance of insects as dye producers is gone. Even lac is of no value except on a small scale. Medicine is still dependent upon insects for Cantharidine, and these beetles may become a source of profit instead of a source of loss. As food, the bodies of insects are valuable to all but the most civilised nations; while a not unimportant branch of trade is the collection of immature *Formicidæ* ("Ant's Eggs") for feeding tame game birds and the capture of flies and other small insects as food for cage birds and the like is carried out on a large scale.

Finally, insects are enrolled, with every other description of natural product, in the list of materials used by woman in her personal adornment. This is not as insignificant as it may appear and, though few insects can be used directly (*e.g.*, Buprestids) many provide models for both art and millinery.

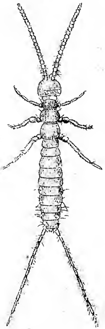


Fig. 1—CAMPODEA STAPHYLINUS × 12.
(*From Lubbock*).

APTERA.

Wingless insects, the mouthparts mandibulate. Antennae and legs simple, the integument soft, clothed in scales or hairs, the segments undifferentiated and little co-adapted. There is no metamorphosis, the development being gradual.

The order includes only a small number of minute wingless insects of extreme delicacy, supposed to be scavengers. The mouthparts are concealed, formed for biting. The legs are often long, and there are frequently abdominal appendages in the form of cerci, springs, etc. The body may be completely clothed with fine scales. There is no metamorphosis and no changes take place in external appearance during life, except growth in size. Most of them live in concealment, their food consisting of dried or decaying vegetable matter, so far as is known. None are of importance economically, one genus, *Lepisma*, being a minor household pest.

Aptera are divided into two suborders and eight families. The *Thysanura* have ten abdominal segments and consist of four families. The *Collembola* have six abdominal segments with a peculiar tube-like structure below the first.

THYSANURA.	*Campodeidæ.* *Japygidæ.* *Machilidæ.* *Lepismidæ.*	COLLEMBOLA.	*Lipuridæ.* *Poduridæ.* *Smynthuridæ.* *Neelidæ.*

CAMPODEIDÆ.

The abdomen terminates in a pair of jointed cerci; the mouthparts are concealed.

The cosmopolitan insect *Campodea staphylinus* Westd. (Fig. 1) or a form very close to it occurs in India in damp moss, among damp decaying vegetation and in similar positions. It is a slender white insect, with moderately long antennæ, with cylindrical body and with two anal cerci.

JAPYGIDÆ.

The mouthparts are concealed. The body terminates in a pair of forceps.

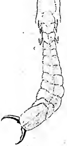


Fig. 2—JAPYX SP. × 8.

These delicate insects will be readily mistaken for young *Forficulidæ*, though the hidden mouthparts serve to distinguish them. They are said to live in moss and under leaves, stones, etc., on the soil, though nothing is on record as to their habits in India. Wood-Mason records finding a single species in Calcutta. (Journ. Asiat. Soc., Bengal, 1876 : Ann. Nat. Hist. IV, 18). *Japyx oudemansi*, Par., and *J. indicus* Oudem., are reported from Burmah. We have found one species (Fig. 2) common among decaying vegetation and in soil; it is a delicate white insect, with the forceps chitinised and brown. It is common in Pusa and in Nagpur, and is probably common throughout the plains.

MACHILIDÆ.

Well developed compound eyes are present. The mouthparts are exserted and visible.

Apparently more than one species of this family occur in India, one on rocks and another among dry decaying leaves.

The latter is a dark grey insect found in the open. The body is elongate, a little over a quarter of an inch long (without the cerci) tapering from the base of the abdomen to head and tail. Compound eyes are situated at the vertex of the head; the antennæ are simple and tapering. The mouthparts are inconspicuous with long maxillary and shorter labial palpi. The body is densely scaled and ends in three

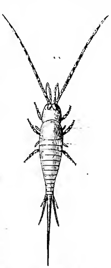


Fig. 3—MACHILIS POLYPODA × 4. (*From Lubbock*).

cerci of which the middle is the longest. On the ventral surface of the second and third thoracic and each abdominal segment is a slender jointed appendage, those on the 6th, 7th and 8th abdominal segments being longest. The legs are simple, tapering, the joints little differentiated, the tarsi two jointed. The female has a straight slender ovipositor. These little insects run on rocks and live in the cracks; they are apparently nocturnal and appear to feed on lichens on the rocks.

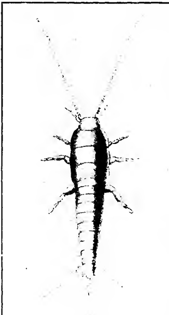


Fig. 4 - LEPISMA SACCHARINA × 6. (*From Lubbock*).

Assmuthia is a termitophilous genus constituted by Escherich for the reception of *A. spinosissima* and *A. inermis* from India (Zool. Anz. 30, p. 744). *Platystelea barbifer*, Esch. is also recorded from nests of termites in India.

LEPISMIDÆ.

Body flattened, clothed in scales; eyes small, mouth-parts exserted.

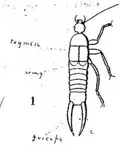
The common fish insects of houses are members of this family and are found throughout India, as practically throughout the world. Annandale has recorded *Lepisma* (*Acrotelsa*) *collaris*, Fabr., as a fish insect of Calcutta (Journ. Asiat. Soc., Bengal, 1906, Vol. II, p. 316), and mentions this as the only recorded Indian species. The Himalayan species is apparently *L. saccharina* (Fig. 4).

Lepismids are common enough, though all may belong to the above species; they shun light, live behind books among paper and in dark corners and are supposed to feed on starchy and sugary matter. Their body is clothed with flat scales which give them a greasy feel and the shiny appearance that characterises them. The surface of paper is commonly eaten by these insects probably because of the material used in glazing it and they can be in this way destructive.

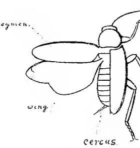
Collembola.

We are not aware of any described Indian species and only a few have been collected or observed. Species of the first two families appear to be common in damp situations as in decaying vegetable matter and wet moss, under stones by streams, where water drips and under bark. In general one finds such conditions for so brief a time in the plains that these delicate insects are probably not abundant, though they are so in the hills.

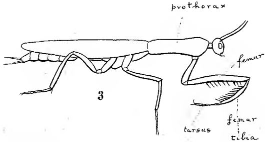
Collecting.—Though of no economic importance, this order is well worth studying. The best method of collecting is to use a camel-hair brush, which is dipped into a mixture of glacial acetic acid and strong alcohol and with which the little insects can be caught and put in a tube of this mixture. They are afterwards transferred to 70% spirit. Berlese's funnel trap is a good method of separating these insects from leaves, moss, etc.


tegmen
wing
forceps

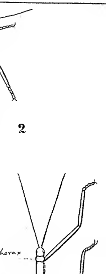
1


tegmen.
wing
cercus

2


prothorax
femur
tarsus
femur
tibia

3


prothorax
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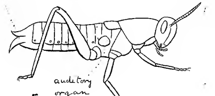
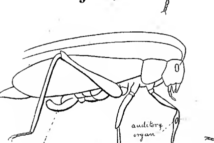
cercus

4


digging processes
auditory organ

5


auditory organ
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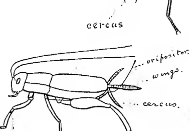
ovipositor.
wings.
cercus.

PLATE I.—ORTHOPTERA

Fig 1. Forficulid. ✓
" 2. Blattid ✓
" 3. Mantid ✓
" 4. Phasmid
" 5. Acridiid
" 6. Locustid
" 7. Gryllid.

ORTHOPTERA.

The antennæ filiform or setaceous, of variable length. The mouthparts mandibulate, of the herbivorous type. The first pair of wings (tegmina) thickened, coloured or ornamented, narrow with nearly parallel sides. The second pair of wings large, membranous, with many fine nervures, hyaline and often coloured, folded below the first pair in repose. The forelegs formed for running or for capturing prey. The hind legs formed for running or leaping, in the latter case long and powerful. Cerci are usually present. There is no perfect metamorphosis, the young differing from the adult chiefly in size, colour and the absence of functional wings and reproductive organs. A small proportion never become winged. The imaginal life is often longer than the nymphal life and occupies the greater part of active life. The order includes moderate to large sized insects, the majority scavengers or herbivores, a part predaceous on other insects. None are aquatic, social, or parasitic in living plants or insects.

The order is divided into seven clearly defined families, four of which form one series in which the hind legs are normal, three of which form a second series in which the hind legs are long and formed for leaping.

HIND LEGS NORMAL.	*Forficulidæ.*	Abdomen terminates in forceps. Tegmina shortened. (Plate 1, fig. 1).
	Blattidæ.	Flattened. head deflexed, coxæ large. (Plate 1, fig. 2).
	Mantidæ.	Forelegs raptorial. Prothorax long. (Plate 1, fig. 3).
	Phasmidæ.	Mesothorax long. (Plate 1, fig. 4).
HIND LEGS FORMED FOR LEAPING.	*Acridiidæ.*	Antennæ short. Auditory organ on abdomen. (Plate 1, fig. 5).
	Locustidæ.	Antennæ long. Auditory organ on fore-tibia. Tarsi four-jointed. (Plate 1, fig. 6).
	Gryllidæ.	Antennæ long.* Auditory organ on fore-tibia. Tarsi three-jointed. Tegmina angled. (Plate 1. fig. 7).

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* Except *Tridactylinæ* recognisable by the absence of hind tarsi and *Gryllotalpa*.

Whilst these families are in the main clearly distinct, their relationships are by no means clear. Many entomologists regard the *Forficulidæ* as a separate order (*Euplexoptera*). *Blattidæ* are a geologically ancient family whose connection with present day insects is not clear. *Phasmidæ* are also an ancient family from which may have branched the *Mantidæ* on one side, the *Acridiidæ* as well as the *Locustidæ* and *Gryllidæ* on the other. The last two are undoubtedly closely allied and such aberrant forms as *Schizodactylus* may well be placed in either.

Gryllidæ is much more an aggregation of divergent tribes which may or may not have a common ancestor and so be included in one family, than is for instance *Acridiidæ* which is a homogenous family. Until further evidence is available, a reasonable view is to regard *Blattidæ* and *Phasmidæ* as two archaic families still existing in a slightly modified form, from the latter of which descended the carnivorous *Mantidæ* on one side, the common ancestor of the *Acridiidæ* and the herbivorous *Locustidæ* on the other, from which we have the carnivorous *Locustidæ*, the burrowing crickets (from some such form as *Schizodactylus*), the various other tribes of *Gryllidæ* from other forms of primitive *Locustidæ*. The *Forficulidæ* are possibly an off-shoot from a primitive form of a Blattid ancestor and although retaining the characters of the primitive Orthopterous ancestor, are now distinct; it is equally probable that they are a distinct family more closely related to the primitive ancestor of the Coleoptera. Whatever view may be held by science when more information is available, these seven families are usefully aggregated in one order and the separate families are, as a rule, easy to distinguish. It is unfortunate that the name *Locusta* should have been applied by Linnæus to an insect that is not sufficiently close to the "locusts" to be in the same family; the result is that taking the family name from the oldest named member, *Locustidæ* does not include "locusts" which are *Acridiidæ*. Entomologists sometimes evade the difficulty by naming the Locustid family *Phasgonuridæ* or by transposing the names and applying the name *Locustidæ* to the *Acridiidæ*. Mr. Kirby calls our Acridiids, *Locustidæ*, our Locustids, *Phasgonuridæ*, and our Gryllids, *Achetidæ*.

The more important papers are the following :—

Stal, Recensio Orthopterorum (1873), Brunner, Revision du Systeme des Orthopteres (1893). Walker—Catalogue of Dermaptera Saltatoria (1869-1871). Bolivar—Orthopteres de St. Joseph's College (Ann. Soc. Ent. France, 1897, p. 282; 1899, p. 761; 1901, p. 580).

FORFICULIDÆ.—*Earwigs.*

Slender insects, the forewings short and covering the hindwings, which are large and radially folded; the abdomen terminates in a pair of processes formed like forceps.

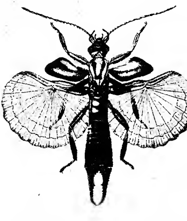


Fig. 5—AN EARWIG WITH EXPANDED WINGS.

The earwigs are medium-sized insects, rarely exceeding half an inch in length, rarely less than one quarter of an inch. The forceps at the extremity of the abdomen is characteristic of the family and while very diverse in form, is at once recognizable. There is a superficial resemblance to the Staphylinid beetles but the latter never have forceps. The colours are sombre, black, brown and chestnut predominating; none are brightly coloured but all have the dull colour of insects that live in concealment or on the surface of the soil.

The head and body are somewhat flattened, the legs of moderate length, adapted to running swiftly on the surface of the soil. The antennæ are about half the length of the body, composed of a number of almost moniliform joints. The mouthparts are of the mandibulate type, the mandibles formed for crushing the food, the labium and maxillæ for further mastication of the crushed food. The labial and maxillary pulps are apparently tactile organs, used to determine the nature of the food. The compound eyes are large with many facets; the thorax is of moderate size, its parts little coadapted; the upper wings (*tegmina*) are short and thickened, rarely covering more than the base of the abdomen. The lower wings fold into small compass, but are large, round, with short radial ribs, the outer part folding back on the basal, the basal folding radially as a fan does; this wing is a beautiful structure, which can be opened with care and in which the method of closing is more complex than in the wings of any other insect. The abdomen is often broader than the rest of the body, the segments imbricate, terminating in the forceps which are in some species half the length of the whole body. These forceps vary immensely in size and structure in different species and are not constant in length even in the same sex of some species. Those of the male are commonly larger; bilateral symmetry is not always preserved, and in a few, one limb crosses the other. The sexes are similar in general appearance; the male, however, having a greater number (nine) of visible ventral segments, the female having only seven. There are wingless forms, also some in which the tegmina are reduced to functionless lobes. These species resemble the young of winged species, but the latter have a softer integument, less developed forceps and a smaller number of joints in the antennæ.

Little is known of the life history and habits of Indian earwigs, though that little agrees with what is known of the family elsewhere. Of these insects, as a whole, it may be said that the round white eggs are laid in a mass in the ground or in shelter, the female in some cases remaining with them until they hatch. The young are white at first and while similar in general form to the adults are likely to be mistaken for Thysanura. The transformation is a gradual one, the number of moults not being known. The following account from Cuvier's Natural History relates to *Forficula auricularia*, Linn. the European Earwig:—

"This curious insect," observes Mr. Kirby, "so unjustly traduced by vulgar prejudice—as if the Creator had willed that the insect world should combine within itself examples of all that is most remarkable in every other department in nature—still more nearly approaches the habits of the hen in the care of her family—she absolutely sets upon her eggs, as if to hatch them—a fact which Frisch appears first to have noticed—and guards them with the greatest care. Degeer, having found an earwig thus occupied, removed her into a box where there was some earth, and scattered the eggs in all directions. She soon, however, collected them, one by one, with her jaws, into a heap, and assiduously sat upon them as before. The young ones which resemble the parent, except in wanting elytra and wings, and, strange to say, are, as soon as born, larger than the eggs which contained them, immediately upon being hatched, creep like a brood of chickens under the belly of the mother who very quietly suffers them to push between her feet and will often, as Degeer found, sit over them in this posture for some hours. This remarkable fact I have myself witnessed, having found an earwig under a stone which accidentally turned over, setting upon a cluster of young ones, just as this celebrated naturalist has described."

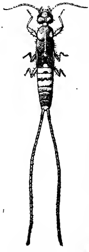


Fig. 6—DIPLATYS LONGISETOSA, NYMPH. (*After Green*).

Diplatys longisetosa, Westw. has a remarkable nymph (fig. 6), in which the abdomen terminates in a pair of long many-jointed processes, of which the basal joint, at the final moult, is transformed into the forceps (Green, Trans. Ent. Soc., London, 1898, p. 381 [Dyscritina]).

Equally little is recorded or known of the food of earwigs. Apparently it consists of decaying vegetable matter, of pollen, of the sap of plants and possibly often of small insects or other small forms of animal life. Earwigs are found in decaying trees, under bark, among rotting vegetation and the deposit of leaves under trees, under stones, in flowers, in the tangled roots of plants (*e.g.*, sugarcane), and in other similar situations; they hide away and live principally under shelter in damp places. Their form is adapted to running quickly and easily among leaves, grass, roots, etc., and flight is but rarely utilised.

Labidura lividipes and *L. riparia*, fly at night and come frequently to light, the only Forficulids observed to have this habit. They are not formed for actual burrowing, but are part of the Fauna of the surface of the ground, as are the *Carabidæ*, *Blattidæ*, *Tenebrionidæ*, *Lygæidæ*, etc.; less is known of this "surface fauna" than of any other, from the great difficulty of observation. The function of the forceps is a mystery that will be cleared up only when their food-habits and general life are better understood. It has been suggested that the forceps, though not actual weapons of defence, appear as such and give the insect a more formidable appearance which protects them against the enemies that occur in their habitat; a few species can actually use their forceps as feeble pinching organs and the power to do so may have been more fully developed in the more primitive species; there is also some reason to believe that the forceps are useful in carrying out the rather complex folding of the hind wing; neither explanation is a satisfactory one.

Earwigs are most active in the rains and damp weather, being dependent upon moderately damp conditions; in irrigated lands they are active throughout the year except when cold drives them to hibernation in shelter, as happens in colder parts of the plains. There appear to be no definite seasons for reproduction, and individuals of different ages may be found at any time. None are recorded as pests in India, though they are often believed to be injurious owing to their habit of coming to wounded tissues of plants to obtain sap; they are thus found under very compromising conditions, but investigation has shown that the injury was caused by other insects, and there is no reason to believe that any can be regarded as pests. A few are constant frequenters of the sea-shore and are found almost throughout the world among the sea-weed and debris thrown up on the beach.

Earwigs are found throughout the temperate and tropical parts of the globe; they are less common in India than in other countries, but a fair number of species are already known from India. They do not fall into well-marked sub-families and may be regarded as a distinct and fairly homogeneous family. Bormans and Krauss describe 76 species from India including Burmah, the majority being Burmese species. Kirby's catalogue gives only 48 as Indian, and more have been described from India by Burr; this does not include species found in Ceylon only. The number of known species will be increased when more attention is paid to this group in India, and some of the commonest species have been found to be undescribed. The student should consult Burr's paper on Ceylon Forficulidæ (Jour. Bombay Nat. Hist. Soc., XIV, 59), his papers on Indian species (Jour. Asiat. Soc. Bengal, 1905, p. 27; and 1906, p. 387); and his revision of part of the family (Trans. Ent. Soc., London, 1907, p. 91).

Diplatys is represented by several sub-tropical species; *D. longisetosa*, Westw. is marked by the long multi-articulate setæ of the nymph, the basal joint of which is stated to become the forceps of the adult. *Forcipula* has three species in India; *Labidura* is represented by several species. *L. riparia*, Pall. *L. bengalensis*, Dohrn. (fig. 7), and *L. lividipes* Duf. are common in grass and are obtainable in numbers when a grass lawn is flooded with water. *Anisolabis maritima*, Gene. is a world-wide species, found in sea-weed on the beach. *A. annulipes*, Luc. is a wingless species, found abundantly in the plains on the soil. *Labia minor*, L., is a common insect not only in Asia but in Europe, Africa and America, found in flowers and on plants, rarely seen on the wing by day. *Chelisoches* is represented by nine species, *C. morio*, Fabr. being spread over the coasts of the South Pacific and Indian Oceans. *C. melanocephalus*, Dohrn. has been found commonly in sugarcane roots and also in the tunnels of the borer caterpillars in the cane. *Apterygida gravidula*, Gerst. is widespread and there are other species of this genus. Several species of *Forficula* are recorded, though the widespread *F. auricularia*, L., the common earwig of Europe, has not been found.

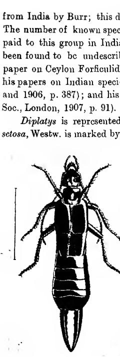


Fig. 7—LABIDURA BENGALENSIS.

Collecting.—Earwigs will be found only by patient search if they are to be specially collected. In the course of general collecting one finds them in flowers, under stones, among decaying vegetation and fallen leaves, among debris on the beach. Some are found in houses, especially in damp places, such as bathrooms in the hot weather; others will be found at the roots of plants in the cold weather. Many come to sap, or are found in bored canes or in other situations where the sap of a plant is exposed. A few come to light, but this is rarely a useful method of collecting them. When caught, they should be killed in a cyanide or B. C. bottle and pinned through the right wingcase. Care is needed to open the left lower wing, though this is not usually necessary.

WHERE INSECTS LIVE.

INSECTS are small creatures and very abundant; where are they all? At some times in the year one can easily gather at least one hundred thousand insects within one day over a space of, say a few acres; at another time there would not appear to be an insect obtainable in that space and yet the insects must be somewhere. It is when one comes to try to answer this question that one realizes the absolute truth of the statement that insects are to be found everywhere on the surface of the earth within a narrow zone which includes 20 feet of the solid soil, the vegetation that stretches up from the soil for some 100 feet, and to a slight extent the air above. Excepting for the moment the artificial erections of man, we are not far from the truth in saying that this zone is very completely occupied by insect life in some form or other. It may be hoped that light will be thrown on this point some day by the very careful investigation of the fauna of, say one square mile of the earth's surface, including this zone we speak of, covering average areas of fallow, crop, grass land, bush, jungle and forest. The number of actual living insects in some form or other will be surprising. Commencing, say 20 feet down, there are the deeply burrowing insects, the termites, the dung beetles, the Cicadid nymphs, and the crickets; within six feet of the surface we come to the insects that burrow, but do not go so deep; the ants are conspicuous examples, as are all the above-mentioned insects which cannot go deep in some soils; Scarabaeid grubs are near the surface, as are Tipulid maggots, Cicindelid grubs; nearer still to the surface are the surface crickets which only make tunnels as shelters, the many digger wasps and other boring Aculeates, the burrows of some Carabids, such as Anthia; quite near the surface our fauna might be immense if we dug in winter, as we should find the countless pupæ of the hibernating beetles, of moths, of Diptera; we should also find the many adults which seek shelter there, as well as abundant egg masses and many half-grown larvæ not yet ready to pupate. At any season there would be many such, not hibernating, but pupating or feeding or in the egg stage. The fauna of these few inches would be of great interest, and we venture to assert that, in India at least, much light would be thrown on many insects' life-histories were it better known. Coming to the actual surface a large fauna would reward us where any fallen leaves and the like offered shelter and food; we have referred often to this fauna, a very extensive medley of black and dark brown insects, such as Earwigs, Cockchafers, Embiids, Carabids, Staphylinids, Clavicornia of many families, Tenebrionid and other beetles, as well as the Cydnine division of the Pentatomidæ, the Lygæidæ, the Reduviids and the Capsids; besides these there are the abundant larvæ of beetles, of Diptera a few of Lepidoptera, probably outnumbering all the remainder and teeming in favourite places. A square foot of good soil covered in leaf mould offers a great variety anywhere, and it is only on very dry or hard soil that one can anywhere find a square foot unoccupied and usually no square inch. This little part of our zone is one centre, the home of the light-shunning surface fauna which works at night and which makes up so large and so unknown a portion of the fauna. It may be noted that this part of our fauna is probably far less important in sub-tropical India than it is in tropical India, the surface fauna in the former being comparatively small. Above that we are on surer ground and the variety is not so confusing; for each part of our plants will have their own fauna; the stems contain borers, the Buprestids, Cerambycids, Pyralids, Cossids and the like; the bark shelters multitudes if it is at all loose or decomposing and here again is a centre of activity, nor rivalling our chief centre but very important and crowded: even the outside of our stems and trunks has cocoons and such like, as well as a whole fauna of its own in the case of a large tree round which debris collects. No one has ever described the fauna of the heap of decaying leaves, bark, etc., found round the base of the trunk of a large pipal, for instance, which is the home of numberless insects, the resting place of pupæ, the place of deposition of eggs. Our low plants have their own fauna, a very large one too, of herbivorous caterpillars, of leafmining Diptera, Coleoptera and Microlepidoptera, of gall insects, of the seed-eating species of caterpillars, of the sucking bugs and aphids; apart from the plant, the two feet or so of air space round the plants teems with the active flying forms, with bees and wasps, with butterflies and beetles, with flies and grasshoppers, all the lives that lives on and round and among low plants. It is this fauna which is, in moist sub-tropical India, with its immense flora, so extensive and which is of much greater relative importance in this zone than it is in tropical India. A reduplication of this fauna is found higher up, in or among the taller forms of vegetation, such as bamboos and grasses and to a large extent this fauna is quite distinct if, as is true, human beings live wholly in the six feet of air space lying immediately over the soil, so also insects are largely restricted each to its particular zone, and we believe there is a very distinct and peculiar fauna of the air at the tree levels: the dancing insects that may be seen in such myriads on a clear still day are certainly peculiar, and it is at least probable that a number never come, in this form, within our ken. but remain at higher levels; then too no one knows what insects are found in the air above the trees or how far this zone extends; what do swallows get when they are hawking high up, far above the trees? Aitken speaks of a butterfly (*Melanitis ismene*) soaring far above into the air and no one knows what countless forms of winged insects may not go to these levels as soon as they emerge. There must be a limit to this zone, but we would hesitate where to put it unless, for the plains, we give an outside limit of, say 3,000 feet. When the day of flying machines dawns we shall certainly find insects of interesting kinds above the trees, and we should like to see "kite" nets employed to investigate the fauna.

It is perhaps not unprofitable to consider, in the light of the above remarks, how little of our insect world we probably know or attempt to know. In this country, progress beyond the stage of classifying and naming the insects most easily got has scarcely been made at all and this must come first; but it is certain that the only insects that have been found, named and placed in Museums are those which fly by day, or which live on bushes, etc., above ground, or which come to light. A great number of insects come to light, notably perhaps a part of the "surface soil fauna" and other retiring insects: but we do not know that there are not hordes which never come to light, which are never seen, and of which we are quite ignorant. This is true probably of all countries and the fauna of the soil, except as regards the large forms, is extremely little known even where naturalists and collectors abound. (The same is to some extent true of freshwater.) How much more will this not be the case with the tropics, especially with the drier parts where much of the fauna is known to go to the soil. We know from experiment that many species go to the surface soil to spend the hot weather; but there are no records that they were ever found there; put out a light trap on a still moist evening during the monsoon and see the countless insects that come and the number of kinds; very many are never found in any other way, yet they and how many more, must be hidden somewhere.

BLATTIDÆ.—*Cockroaches.*

Flattened insects, the large forewings lying flat on the abdomen, completely covering the hindwings. Coxæ large and covering the lower surface of the thorax. The head turned down and hidden from above.

Cockroaches have a very characteristic general appearance and are usually recognizable at sight; they include small fragile insects of a the end of the following April. The young which emerge from the egg-capsule are in general form similar to the adult, the skin softer, the antennæ and cerci with fewer joints, the wings absent. The number of moults is not known; in captivity, development is slow, the common household species (*Periplaneta americana*), requiring several months to come to maturity. There is reason to believe this is the case also with the free-living species, and since the possession of wings is usually a matter of slight importance and the habits remain unchanged, there would not appear to be any necessity for quick nymphal development. The total length of the life history is not known, but the imaginal, like the nymphal, life is probably comparatively long.

In all stages, cockroaches are found amongst fallen leaves, on the surface of the soil, under stones, in thick grass, and on trees and plants. The majority are nocturnal, living in concealment on the surface of the soil and forming a part of the large "surface fauna." The tree and bush species are diurnal in habit. A few are household insects living in buildings and these are undoubtedly wild free-living species which have migrated into man's dwellings. The food consists of dead animal and vegetable matter; these insects are "scavengers" and none is known to feed on living plant tissue or to attack living insects. Plant sap, decaying plant tissue, dead insects and the like probably represents the food of the free-living species. The household species have the same food-habits, a great variety of animal and vegetable substances forming their food while their dead brethren are freely eaten when hunger presses. Nothing is known as to the activities of Indian species during the different seasons. Hibernation, where necessary, is apparently passed in any stage and there appear to be no special "seasons" when cockroaches breed. Excessive cold, excessive heat, drought or hunger cause a cessation of reproduction, development and activity but no definite seasons have been made out. No species is known as a pest, though those which live in houses are objectionable and destructive.

Since these insects are dependent upon crumbs, scraps, and access to human food, cleanliness and care should prevent them thriving. Where they are abundant, the simplest precaution is the use of borax, mixed with double its weight of syrup, as a poison; many ingenious traps are also useful when baited with intoxicating liquor. The principal check on cockroaches are egg-parasites; the ichneumons of the genus *Evania* lay their eggs in the egg capsules of cockroaches and the household species are not exempt from attack. Field cockroaches are attacked by fossorial wasps of the genus *Ampulex*, which sting them, deposit them in holes or crevices and lay an egg on them. The unpleasant odour of the household cockroaches is probably protective and is due to the secretion of liquid from glands placed between the 5th and 6th abdominal segments. (Minchin, Q. J. M. S., XXIX.)

It is known that cockroaches contain internal parasites belonging to the Gregarine division of the Protozoa, as well as parasitic bacteria, Nematodes (*Oxyuris*), Hair worms (*Gordius*) and a *Filaria*. It is also probable that the large centipedes which enter houses in India are seeking blattids. Rats also feed on cockroaches.

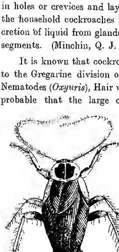


Fig. 10—PHYLLODROMIA HUMBERTIANA. × 2½.

The family is a comparatively large one, with many described species, occurring in all parts of the globe. The majority of the Indian species are described by Brunner and Bolivar.

Kirby's recent catalogue of the family lists 123 Indian species, which probably include the majority of the larger forms. The family is being listed by R. Shelford in Genera Insectorum; it is divided into eleven tribes by Brunner, but it is unnecessary to consider these in this place. *Phyllodromia* (Blatta) *germanica*, Linn. is one of the common small species found in houses in India and now cosmopolitan, probably introduced to India from Europe. *P. humbertiana*, Sauss. (*cognata*) (fig. 10) is a small brown species, the prothorax marked with black and light brown. It is perhaps the most common field species, found among decaying vegetation and also on trees; its eggs are laid on the leaves and bark of trees. On the soil is its wingless nymph, a small black insect with median and lateral light stripes. *Phyllodromia suppellectilium*, Serv., is the small household species, common throughout the tropics; it is winged, of a brown colour with varied dark markings.

Stylopyga (Blatta) *orientalis*, Linn. is a widespread species, believed to have been introduced to Europe from tropical Asia and now carried over the world in ships. It is a dark coloured insect of a length of a little over an inch; the tegmina do not reach to the apex of the abdomen and cover only the basal five segments. The males alone are winged. The development in Europe is stated to occupy as much as four years, the duration of each instar being very long. *Stylopyga rhombifolia*, Stoll. (fig. 9) is a larger wingless form, brown, with varied yellow markings, found also in houses. This is the most common household species next to the large winged *Periplaneta australasiæ*, F. *Periplaneta* includes the two large cockroaches so common in houses and on board ships. Both are winged, red brown with lighter markings on the prothorax. *P. australasiæ*, Fabr. (fig. 11) is smaller than *P. americana*, Linn. the prothorax more wholly dark. The latter has the startling habit of flying about in the house before rain falls and is accounted a reliable weather prophet. This habit is possibly a relic of the instinct of its original free-living ancestor, which flew up into safety before the fall of heavy rain. *Rhyparobia maderæ*, Fabr. is a cosmopolitan species, carried over the world by commerce. *Leucophæa surinamensis*, Linn. is a smaller thickset insect, the prothorax black, the tegmina brown; it is common in the open and is widespread over the tropics. *Panesthia regalis*, Wlk. is a peculiarly striking species, black with a broad band of orange across the tegmina. It is one of the rarer plains' species. *Corydia petiveriana*, Linn. is a beautiful cockroach of South India, the tegmina having large white spots. *Heterogamia* (Polyphaga) *indica*, Wlk. resembles a large round woodlouse, wingless and nearly circular in outline.

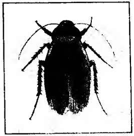


Fig. 11—PERIPLANETA AUSTRALASIÆ.

Collecting.—Cockroaches are found by searching under stones, among fallen leaves, on herbage and bushes, on the bark of trees, and among the debris that accumulates at the foot of the trunk of a large tree. The smaller ones are found also in thick (doab) grass in the hot weather. Syrup or fruit juice smeared on the bark of trees is a good bait but unless this is alcoholised, it must be examined soon after dark; if strongly alcoholised the insects get drunk and may be found at any time in the night till dawn. A few species are attracted by light. When caught and killed, they should be pinned through the right tegmen near the base, the legs and antennæ set. Rearing is slow and difficult; the right conditions of moisture and food must be given with plenty of shelter and space.

COSMOPOLITAN INSECTS.

A CONSIDERABLE number of insects have been carried by man from one country to another and have succeeded in establishing themselves not in one country only but in a large number of countries; the spread of these insects is continuing and they will in time be world wide. These species are to a large extent those which can live in houses, or which infest grain and other merchandise, or which have been carried on living animals and plants. Naturally the household and grain insects predominate, since commerce is carried on between large cities in which these insects thrive, whereas those infesting plants have not the same chance of surviving in all cases. Many of our common household insects are cosmopolitan; the common silver fish of houses is now widespread and will become more so; the Cockroaches, *Stylopyga orientalis, Periplaneta americana* and *P. australasiæ, Rhyparobia maderæ and Leucophæa surinamensis*, are common in India as elsewhere; with them have gone their parasite *Evania appendigaster*, now a common insect and met with on board ship. It is probable that our household *Psocids* are also the same as the European though we are not aware that this has yet been substantiated. Ants, (*e.g., Monomorium*) as is well known, constantly come with shipments of goods and establish themselves successfully in new cities.

A host of beetles are cosmopolites. Hamilton gives a list of 100 beetles which he styles eosmopolite or nearly so; this refers more especially to Europe and North America and indicates how large a number of insects have been carried by commerce and have succeeded in establishing themselves in new countries. Only a small number of these appear to originate in the East.

The following are Cosmopolitan beetles apparently found in India, some possibly originating there (indicated by*).

Silvanus surinamensis.
Læmophlœus ferrugineus.
,, *pusillus.*
Dermestes vulpinus.
Carpophilus hemipterus.
Trogosita mauritanico.
Necrobia rufipes.
Necrobia ruficollis.
Necrobia violacea.
Gibbium scotias.

* *Sitodrepa panicea.*
Dinoderus pusillus.
Bruchus chinensis.
,, *emarginatus.*
* *Tenebrio molitor Linn.*
* *Tribolium ferrugineum.*
* ,, *confusum.*
* *Calandra oryzæ.*
* ,, *granaria.*
Aræcerus fasciculatus.

Among Lepidoptera some of the genus *Ephestia* are constantly carried and are now almost universal; so also are such forms as *Tinea pellionella*, *Setomorpha rutella*, and other clothes moths. Of the flies, we know of few; *Eristalis tenax* is widespread and the common houseflies such as *Musca domestica* are world wide, as are some of the fleas; the cheese maggot, *Piophila casei* is also carried in its food and establishes itself successfully.

Finally the malodorous bug *Cimex lectularius* is sufficiently familiar. The above are all household or grain pests and would naturally be readily spread. Amongst animal pests it is sufficient to mention the fly *Stomoxys calcitrans* established throughout India, as well as the three bot flies of the horse, cow and sheep, (ticks also are carried). When we turn to plant parasites, there are fewer true cosmopolites since the vegetation varies so much, and since climatic conditions affect the insects more. (See Agric. Journ., India, III, No. 3. "Introduced Insect Pests.") Many scale insects are extremely widespread and numerous species are known to have been carried, some reaching India. In fact, the introduction of living plants is practically certain to mean the introduction of scale insects if precautions are not taken. We can enumerate 25 species probably introduced to or from India, and we have seen more than one on consignment of plants from abroad. How our Aphids reached India is not clear but our worst are all cosmopolites and have probably come on plants. Of other insects, it is extremely hard to speak; a few are cosmopolitan, such as *Chloridea obsoleta*, *Danais plexippus*, *Vanessa cardui*, *Hellula undalis*. *Nomophila noctuella*, *Plutella maculipennis*, but there is no evidence that they are spread by man and this cosmopolitanism possibly antedates man. *Phthorimæa operculella* is a widespread insect introduced to India probably in recent years and is the sole instance of its class we know of.

We have barely touched the fringe of this subject as alone is possible in this place. Enough has been said to show that insects are carried by man and though India has not suffered from this cause, as for instance, America and the West Indies have, yet when more is known it may be found that India has got nearly as much as she has given.

MANTIDÆ.—*Preying Mantises.*

The forelegs raptorial, long, the femora and tibiæ spiny. The head deflexed. The prothorax elongate.

A moderately large family, recognizable by the raptorial forelegs, in which the tibia works in opposition to the femur like the blades of a scissors, and both are wholly or partially spined. Where this character is insufficient to separate from *Phasmidæ*, the length of the prothorax is sufficient, this being short in the latter family. Mantises are commonly of large size and include no insects of less length than half an inch while some attain to four and even six inches. In appearance, these insects are extremely striking, including some of the most picturesque and bizarre forms of insect life. The form and colour is cryptic, designed to produce a resemblance to natural objects in their surroundings which is extremely marked. Many are stick-like, elongate, coloured in tones of brown and black as is a dry twig; in these, the attitude assists the deception, the creature poising itself on its posterior legs and swaying

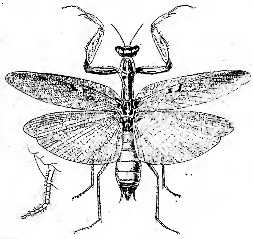


Fig. 12—HIERODULA COARCTATA.
And left cercus.

lightly from side to side as if moved by the breeze. Others that live in grass are slender and grass coloured, either "dry grass colour," green or green with the antennæ and cerci coloured like the dry tips of withered grass. Others are leaf green, living among the leaves of bushes or are the colour of bark and are found on tree trunks. The most striking instance is the Orchid mantis, *Gongylus gongyloides*, which is a floral simulator, the body and wings so formed as to suggest a flower when a particular attitude is assumed. In this attitude, the lower surface suggests a blue flower, and insects coming to it are destroyed by the forelegs. Williams (Trans. Ent. Soc. Lond., 1904, p. 125) states that the upper surface can be so arranged as to simulate an orchid flower, this being primarily as a means of defence (cryptic), the blue flower resemblance alone being used to obtain food. In general the cryptic form and colour serves the double object of protecting the insect from foes and allowing it to be invisible to other insects which it captures when they come within reach.

The antennæ are filiform, in some short and inconspicuous, in others long. The head is elongate, sometimes produced at the apex, the compound eyes are large, the head very mobile and the insect has a curious habit of turning the head to look intelligently even at a human being as if it really saw it. The mouthparts are similar to those of the rest of the order, short biting mouthparts, the mandibles not elongate as in other predaceous insects, since the prey is captured by the forelegs and the jaws are solely for mastication. The prothorax is long, sometimes nearly half the length of the body, and this is apparently an adaptation to secure great mobility for the forelegs and head. The forewings are of moderate size, thickened, coloured and covering the large folded hindwings, which are hyaline and often coloured. Wingless species occur but rarely, one or both sexes being without either tegmina or wings. Wood-Mason describes stridulatory structures in certain *Mantidæ*, but there appears to be no direct evidence that sounds are actually produced (Trans. Ent. Soc. London, 1878, p. 263). The abdomen is often expanded in a leaf-like manner and is carried in striking attitudes to aid the cryptic resemblance. The abdomen terminates in a pair of short cerci. The forelegs are beautifully formed, the tibia closing on to the femur; as both are set with spines, an insect caught in them is firmly held and can be brought up to the mouth to be eaten. The tibia is sometimes as long as the femur, sometimes very short and only closing on the apex of the femur, this portion of the femur alone being spined, the remainder smooth. Wood-Mason describes femoral brushes used to keep the eyes and ocelli clean and found, he says, in the nymphs just hatched and in all later stages (Proc. Asiat. Soc. Bengal, 1876, p. 123). The posterior legs are long and enable the insect to run actively, as well as to balance itself ready to turn or to dart forward. There are few more striking insects than a mantis in its natural habitat on a plant waiting for food ; balanced on the two pairs of legs, it looks from side to side, turning the head with quick motions and seeming to look intently from the large eyes ; the antennæ are active, moving constantly, the forelegs drawn up under the head but ready to dart out ; the creature is so intent, the attitude so expectant and yet suggestive of cunning ; in an instant it stiffens, becomes rigid, every part still, the long forelegs extended; should its prey alight near, it moves stealthily, stalking it as a cat does a bird, gradually drawing near

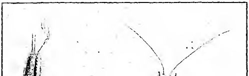


Fig. 13—MANTID EGG-MASS AND NEWLY EMERGED NYMPH, THE LATTER MUCH ENLARGED.

till its forelegs strike and the insect is held securely, drawn up to the mouth and devoured.

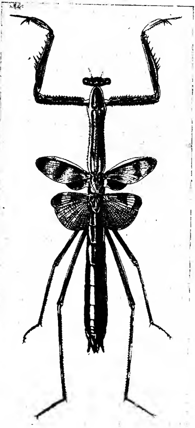


Fig. 14—DEIPHOBE OCELLATA.

The female deposits her eggs in a characteristic large egg case, (fig. 13) fixed to a plant. The egg case is made of gummy matter secreted by the female, which comes out as a frothy mass, and sets hard in a short time; taking a firm position on the plant, with head down and the tip of the abdomen touching the plant, she extrudes a mass of frothy gum and with the end of the abdomen works it into the shape characteristic; as soon as the base is formed and some amount of gum used, eggs are deposited in the midst of the gum. The emission of eggs and gum continues, the eggs in the middle, the gum round, until the whole egg mass is built up, layer by layer, when she finishes it off with gum and the whole hardens to a watertight object firmly secured to the plant. The eggs are in regular rows inside the egg case and the whole mass will last through the winter on the plant. The young mantids emerge from the egg almost simultaneously and are small active insects often dark coloured and with a general resemblance to an ant (fig. 13). Shelford records the mimicry of the nymph of *Hymenopus bicornus* for the nymph of a Reduviid bug, *Eulyes amoena* (Proc. Zool. Soc. London, 1902, p. 230). They are active and lead an active life until they are full grown. In general their habits are not those of the parents, the young seeking small insects on plants or on the soil, and only adopting the peculiar habits of their parents as they progress towards maturity. The form and attitude of the young is frequently very striking, though different to that of the adult, and there is a large field for investigation into the habits and resemblances of these nymphs. All are predaceous at all times of their life; the food of the full grown insect is large living insects, which are caught when they come within reach of the waiting mantis. None are vegetarian, none are injurious, but the group comes into the class we may denominate as "General Predators," feeding on such insects as come to them and not being specially adapted to special insects. The length of the life history is not known. Hibernation appears to take place chiefly in the egg stage; eggmasses are laid in early November in the plains, and hatch in early March. This is not the only time that eggs are laid, as they may be found during the rains. Wood-Mason found eggs laid by *Mantis* sp. to hatch in 18 days (July 17th to August 4th), while those of *Schizocephola bicornis* took 30 days (July 17th to August 16th). Nymphs and adults of bark-infesting species have been found in winter under the bark of trees, and this appears to be the normal hibernation of such as can find shelter. Throughout the remaining months these insects are active and there appear to be no special periods when they breed or multiply extensively. They are distributed throughout India, more abundantly in the jungle but still commonly in the cultivated plains. They are essentially tropical insects, and are rare or non-existent in temperate climates. The eggmasses are the habitat of parasitic *Chalcidæ*, the females of which have long ovipositors with which they pierce the eggmass and reach the eggs within. Apparently a large proportion of the eggmasses are parasitised. Other enemies are not known.

Mantidæ are far less numerous than some other groups of Orthoptera and fewer species occur.

Wood-Mason catalogued the *Mantidæ* and more recently Mr. Kirby's catalogue has been issued by the British Museum (Cat. of Orth., pt. 1). In this 82 species are listed as Indian divided as follows :—

Amorphoscelinæ 1, Hemiaphilinæ 7, Chaeradodinæ 1, Mantinæ 43, Miopteryginæ 0, Creobotinæ 17, Vatinæ 10, Empusiinæ 3.

The majority of Indian Mantidæ belong to genera widespread over the Indo-Malayan region. Five genera are purely Indian, accepting India in the broad sense, these being *Sphendale, Phyllothelys, Heterochaetula, Aethalochroa* and *Gongylus*. *Empusa* is widespread, having but one Indian species, but occurring also in Africa, South Europe and Western Asia.

Creoboter urbana, Fabr. is a common small green form, each tegmen with a yellow black-ringed eye-spot; it is an active species found upon bushes. *Hierodula Westwoodi*, Sss. and *H. coarctata*, Westw. (fig. 12) are the robuster green insect seen upon bushes and in crops, which are the most familiar "Mantis" in India. The former has been seen eating *Scutellera nobilis*. *Eremoplana microptera*, Wlk. is a long slender species of a dull brown colour with a narrow green costal stripe, found upon low bushes in the plains. It comes freely to light. *Humbertiella indica*, Sss. is a smaller dull grey species found upon the bark of trees, where its colouring renders it very inconspicuous. *Schizocephalus bicornis*, L. is one of the most delightful of the insects one can find commonly in the plains. It is a very long, attenuated insect, with long slender legs, and with short wings folding tightly round the body. Its colouring is green and the antennæ and anal cerci are both the colour of a dry grass blade. Sitting among the grass, the insect is indistinguishable from the grass blades round it; its antennæ or anal cerci give the idea of grass just drying at the tip and one may search for these insects and not find one when they are abundant under one's eyes at the time. They are slow in movement and the femur is armed only at the tip, the tibia very short.

Two species of *Gongylus* occur in India, of which we figure one. *G. gongyloides*, Linn. (fig. 15) is a notorious insect of which much has been written. *G. trachelophyllus*, Burm. is the commoner Indian insect, a graceful creature coloured in tints of yellow and brown and commonly found in jungles and woods.

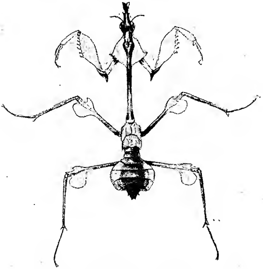


Fig. 15—GONGYLUS GONGYLOIDES.

Collecting.—The great number of mantids are found upon bushes, in grass, on the bark of trees. They are most abundant upon bushes, rare upon small crops. A number will be found in the bag when it is used to sweep insects on grass. These insects should never be included with others in a box or bottle while alive, but should be confined separately or at once killed. They are best pinned through the right wing case or prothorax, the left wings being set. Rearing is exceedingly difficult in most cases, though the eggs hatch readily, as the special food of the young cannot be ascertained or easily procured. What is now specially required is careful observation of the food of these insects; we are not aware of any definite observations on the food of individual Indian species and no proper estimate of their economic value can be made until we have such facts.

PHASMIDÆ.—*Stick and leaf insects.*

The prothorax small, mesothorax large. Tegmina small or absent; wings often absent. Cerci of one joint only.

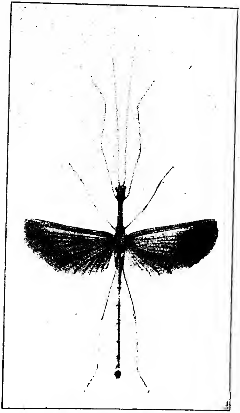


Fig. 16—NECROSCIA PHOLIDOTUS, WESTW., MALE.

A smaller group of insects, distinct from *Mantidæ* by the small prothorax and by the forelegs which are not formed for the capture of prey; they are distinct from the jumping Orthoptera by the hind legs, which are not formed for leaping. None of these insects are small, whilst some are of great length, four to six inches being the usual size for the full grown ones. They present a great variety of form and colour, some being stick-like, others leaf-like or resembling a blade of grass, while others closely resemble other natural objects. The colour schemes bear out this cryptic form and their whole appearance is designed to give them so close a resemblance to their habitat that they will escape the observation of their foes.

The antennæ are commonly many jointed and long. The head is small, and not deflexed. The mesothorax is long, as is usually the metathorax in the elongated species. The legs are long, formed for walking and without special structures. The tegmina are small or wholly absent, even in forms which have large hindwings. In many species the wings are wholly absent either in both sexes, or in the female only. The male has claspers at the end of the abdomen, the female a ventral process which directs the eggs as they are extruded. The differences between the sexes are often very great, the male small, active and winged; the female large, clumsy and unwinged.

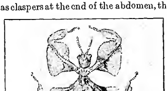


Fig. 17—PHYLLIUM SCYTHE, NYMPH.

The eggs are laid singly, dropped like seeds upon the ground. They are often of peculiar form, with very thick covering, and closely resembling hard seeds. Little is known of the life history of Indian species. The young are similar to the adult and are stated to develop slowly. There is a line of weakness (suture) between the trochanter and femur, which enables the insect to throw off a leg with ease, this leg being later formed anew. It has been observed that not only is this useful as a protection from enemies but also in moulting, as few Phasmids can moult successfully without remaining attached to the cast skin by a leg, and this adaptation enables the moult to be completed, though with the loss of a limb. (Bordage.) The food is apparently wholly vegetable and no cases are recorded of these insects being carnivorous; they eat the leaves of plants and some possibly feed upon lichens. None are injurious in India and their habitat is practically confined to the forest and jungle areas of the warmer parts of India. Not much is known of

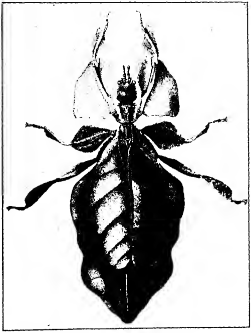


Fig. 18—PHYLLIUM SCYTHE.

Indian species and none are likely to be found in the cultivated areas. Westwood figures a number of Indian species (Cab. Or. Entom., 1847). Brunner listed 19 from Burma, and Bolivar 26 from South India. Kirby's Catalogue enumerates 65 Indian species.

Pulchriphyllium (*Phyllium*) *scythe* Gr. (figs. 17, 18) is a large leaf-like insect, whose life history is described by Murray and quoted in Sharp's Insects. It occurs in forest areas in Assam.

ACRIDIIDÆ.—*Short-horned Grasshoppers.*

The antennæ short; the auditory organ on the first abdominal segment; the ovipositor composed of short valves formed for digging; tarsi three-jointed. Hind legs long, and saltatorial.

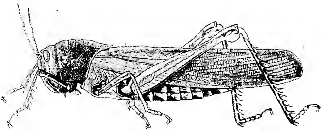


Fig. 19—ACRIDIUM MELANOCORNE.

A family which can scarcely ever be confused in the field; the short antennæ and leaping hind legs mark a true grasshopper at once. The size varies from a length of a quarter and a wing span of nearly half an inch to a length of over two inches and a wing span of three to four. The majority are less than one inch long, the smallest among the Tetriginæ, the largest among the Acridiinæ. Size is usually sufficiently constant to be valuable as an indication of species. With few exceptions the colour is cryptic; the colour schemes harmonize so closely with the natural surroundings that the insects are difficult to see. Since the life is a long one and the surroundings vary with the change of season, it is common to find that, while the nymph is also cryptically coloured, the colour may not be the same as that of the imago. There may be two or more actual colour schemes in the whole life, both cryptic and adapted to changes of season. Young grasshoppers hatching in the rains are frequently green to harmonize with the growing vegetation; this often gives place to "dry grass colour" in the adult which is found in October. Others which live on dry soil, on rocks, on moors, on sand dunes are coloured in shades of grey and brown with lighter markings and spots; in nearly all the colours are dull, and though varied, evidently cryptic. In the true locusts further and more striking colour changes take place, one of which is the "swarming colour," a vivid red, that probably facilitates migration by rendering the swarm visible at a distance and enabling all to join it. A very few are vividly coloured and undoubtedly exhibit warning colouring; this is correlated with the habit of living exposed on the plant and the young are also warningly coloured, though not always in the same tints as the adult. In a large number of cryptically coloured forms, we find that the lower wings are brightly coloured; in flight this colour is very conspicuous and it is not difficult to follow the jerky zigzag flight with the eye; but as the wings close on the insect settling, all trace of the colour is lost, the tints of the upper wings and body blend with the surroundings, the insect sits still and vanishes before one's eyes. There is no doubt that the bright colours of the lower wings, which sometimes extend to the sides of the abdomen, are "deceptive" and materially assist in the escape of the grasshopper

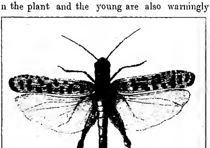


Fig. 20—Tylotropidius didymus.

from birds or other enemies. Although the general form of the body is usually uniform throughout the family, a few are modified in connection with their habits. Thus the surface grasshoppers (*Chrotogonus*) which live on the soil are very much flattened, the prothorax and tegmina roughened. Some of the species that live among long grass are elongated, the body cylindrical, admirably adapted to cling to and resemble the long grass stems.

As in other Orthoptera, the chitinous integument preserves the primitive form of the lower insects, the segments being easily distinguishable, the plates little differentiated. The head is of moderate size, distinct from the thorax, with large compound eyes and three ocelli. The antennæ are filiform, with less than thirty joints, flattened in some species. The mouthparts are of the herbivorous type, the upper lip (labrum) well developed, the mandibles large with cutting teeth, the maxillæ and labium distinct, fitted for mastication and bearing sensory palpi. The hypopharynx is well developed as a blunt tongue-like organ on the floor of the mouth. The prothorax is large, its form and markings useful in the discrimination of genera. In one sub-family (*Tetriginæ*) the pronotum is produced backwards as a long process between and over the wings (fig. 21). In some sub-families there is a tubercle or tooth-like projection on the prosternum between the base of the forelegs. The meso- and meta-thorax are distinct, covered by the tegmina, which are long and narrow, opaque and variously coloured or ornamented. In many species they project beyond the abdomen, in others they are shorter. In the *Tetriginæ* they are reduced to tiny lobes and the wings are covered by the prolongation of the pronotum (fig. 21). In some species

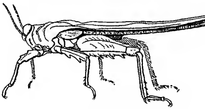


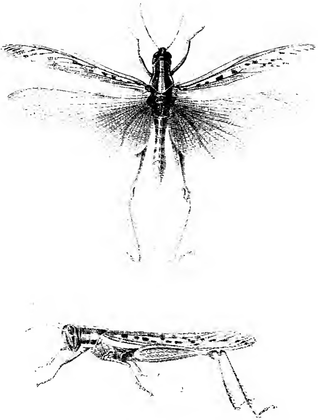
Fig. 21—SCELIMENA LOGANI.
(*After Hancock.*)

PLATE III.—THE BOMBAY LOCUST.

ACRIDIUM SUCCINCTUM.

Fig. 13. } The Bombay Locust as ordinarily found when it does not
" 14. } swarm and change colour.

(Reprinted from *The Agricultural Journal of India.*)



THE BOMBAY LOCUST.

wings are short or reduced, the tegmina reduced to lobes or only partially developed. In the majority the wings are large, hyaline and many-veined, folding under the tegmina; they are frequently coloured at the base with red, yellow or black. The tegmina and wings in flight function as one. The abdomen is long, the segments distinct; it contracts and expands telescopically to a great extent in the female, in copulation being excessively retracted, in oviposition extremely elongated. The external genital organs are well marked; the principal features of the female are the upper and lower chitinous valves, which are used for digging, the anus being above, the genital aperture below. In the male, the genital aperture is on the upper surface of the usually conspicuous ventral shield, which often ends in a point. There is a small pair of cerci on the apex of the abdomen at each side of the anus. Males and females are frequently of different sizes and also of different colours. The anterior legs are short, fitted for slow walking and clinging; the hind legs are conspicuous by the great development of the femur and tibia; the tibia bends back on to the femur, the apex of the former reaching the base of the latter and from this attitude the tibia kicks back, giving the impetus of the leaping motion. The tibia is outwardly set with thick spines. The femur may be specially modified to produce vibration when rubbed against the tegmen. The inner face of the femur bears a row of knobs; the femur is rubbed up and down against a projecting vein of the tegmen, causing the latter to vibrate. Under the tegmen, on the side of the basal abdominal segment, may be seen the auditory organ, visible as a round depression in the integument, and containing the tightly stretched tympanal membrane. Spiracles are situated on the thorax and on the membrane connecting the notum and sternum of the first eight abdominal segments. The tracheal system is characterised by having bladder-like dilatations of some of the vessels, which are inflated previous to flight and while increasing the bulk of the insect, diminish its specific gravity and facilitate flight.

The life history of the known Indian grasshoppers is uniform in the main outlines but only a small proportion have been worked out. Eggs are, so far as known, universally deposited in the soil in a compact cluster, with gummy matter which hardens and compacts the mass (fig. 22). The number varies with the species, and all are not necessarily laid in one mass. About sixty eggs are laid by Hieroglyphus about 100-120 by Acridium. The eggs remain in the soil for a considerable period, and loosen slightly owing to their expansion before hatching. The young hoppers have the general form of the adult, the antennæ with fewer joints, the wings and internal genital system absent. The number of moults is generally from five to seven, the wings appearing as lobes at the third or fourth moult. The nymphs are active from the first; the colouring, as stated above, may change during nymphal life or may change slowly until with the penultimate moult the colour approximates to that of the imago. The duration of the nymphal stage varies with individual species but is usually long.

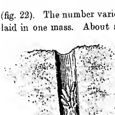


Fig. 22—CHROTOGONUS TRACHYPTERUS, EGGS IN SOIL. xl.

It is at present impossible to generalise as to the duration of each stage of the life of these insects. Apparently most have definite seasons for reproduction, governed by climatic conditions and which are rigorously adhered to. Thus some have but one brood in a year, the three stages occupying the whole twelve months; the Bombay Locust lays eggs in June, which hatch in July (after six weeks), the nymphal development is completed in late September and the imago lives until the following June: the Rice Grasshopper on the other hand remains in the egg stage from October to June and the nymphal and imaginal life occupy about four and a half months. There are probably many grasshoppers having only one brood yearly. Others have two, as does the Migratory Locust, the imaginal life being longest, but the two broods of about equal length. Others appear to have two broods during the rains, but the eggs laid by the second brood in November remain dormant until the following rains; in this case the two broods are of unequal length. A number probably will be found to agree with these, having two or more broods from June to November, or from March to November, but always one hibernation brood which passes the cold weather, and generally the hot dry weather in the egg stage. A number have several broods a year

PLATE IV.—The Migratory Locust

Acridium (Schistocerca) Peregrinum.

Fig. 15. Migratory Locust Hopper, in first stage, magnified five times.

„ 16. Migratory Locust Hopper, in second stage, magnified four times.

„ 17. Migratory Locust Hopper, in third stage, magnified three times.

„ 18. Migratory Locust Hopper, in fourth stage, magnified 2½ times.

(Reprinted from *The Agricultural Journal of India*.)

but apparently have no regular seasons. They breed throughout the year except in the very cold weather and probably not when food is scarce. The Black Spotted Grasshopper (*Cyrtacanthacris ranacea* stoll) is an example, as are the species of *Chrotogonus* and *Atractomorpha crenulata*. Hibernation and æstivation appear to be passed almost wholly in the egg in the plains, only a small proportion as imagines; this varies however with different degrees of cold and dryness in different localities. A few hibernate as imagines or nymphs in the colder parts of the plains. Apparently there is a great variety in this respect and a far larger number of species require to be worked out before one can generalise on this point. So far as known no Acridiid is anything but herbivorous, feeding on green plants; some have a single food plant, others several and many appear to be to some extent omnivorous. Grasses and gramineous crops are the principal food plants but flowering plants, shrubs and bushes are not exempt. Locusts have a very wide range of food plants.

Nymphs and adults live free lives, and are found wherever there is vegetation. The greater number are to be found in grasslands, in open waste lands, among low herbage. Others live among shrubs, a few on trees. Open moors, sand dunes, fallow land also contain other species and they range from the plains to considerable altitudes in the hills, with their maximum development in the grasslands of the plains. This is one of the few families in which the number of purely "plains species" is as great as the number found in submontane forest and jungle areas.

This family, being wholly herbivorous and very abundant, is one of the most injurious to Agriculture. Besides the two locusts, there are grasshoppers which attack special crops and the many species, which when abundant, attack gramineous crops. Few of these are specific pests of particular crops, they occur spasmodically and irregularly and, since grasshoppers are of universal occurrence, nothing is done to check them until they are already abundantly destructive. A distinct class of pest are the Surface Grasshoppers, species belonging to the genera *Chrotogonus*, *Epacromia*, *Atractomorpha*, which live on the soil and attack young crops. Little is known of which species of grasshopper are destructive since the actually destructive species is not always the one sent in as destructive and there is here a large field for research. The student may be cautioned against accepting the reports of injury by Acridiids in Indian Museum Notes; often an entirely harmless species is sent in, being the first one to come to hand. Not more than two locusts and six grasshoppers are actually and positively known to be injurious in India.

Whilst there is some information available as to the enemies of the two locusts, little is known of the checks on the increase of the family as a whole. The eggs of the locusts are attacked by Hymenopterous parasites, the young by ground beetles (*Carabidæ*), the adults by parasitic insects and the young of a mite (*Trombidium grandissimum*, Koch.). An Oligochæt worm (*Henleya Lefroyi*, Bedd.) has been found destroying the eggs of one locust and probably attacks those of other Acridiids. Birds, monkeys and squirrels feed on locusts and the larger grasshoppers; mynas, hoopooes and other birds eat hoppers and fossorial wasps store their nests with small hoppers. Certain fly and beetle grubs attack the eggs, but while these are probably insects of the families *Bombyliidæ* and *Cantharidæ*, respectively, the species concerned are not known.

The family is a very large one, the largest of the Orthoptera, but no complete list exists. It is universally distributed through the tropical and temperate zones, with a large number of species. Indian forms are largely Indo-Malayan, or have a wide distribution over Southern and Eastern Asia; a few are European and African. In India, the species are, so far as known, widely spread and not local, though Burmah appears to have many species not found in India. No catalogue of Indian species has been compiled and the information is buried in the literature of the past century. (See page 48.) Bolivar records 100 species from a small area of South India, Brunner records 157 from Burmah. There are probably 500 recorded Indian species and at least 1,000 now existing in India. Brunner divides the family into nine subfamilies, which are on the whole well marked. Indian species fall mainly into five of these, the characters of which are as follows:—

Tetriginæ. The pronotum produced backwards over the abdomen, the tegmina lobelike, no pulvillus.

Pneumorinæ (African).

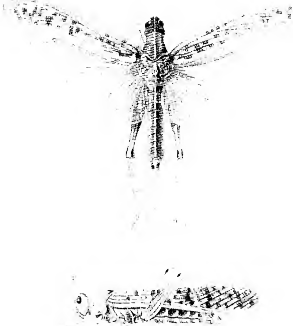
Mastacinæ. Antennæ shorter than the anterior femora. Head short.

PLATE V.—MIGRATORY LOCUST.

ACRIDIUM (SCHISTOCERCA) PEREGRINUM

Fig. 19. Migratory Locust in swarming colouration.
,, 20. The same in egg laying colouration.

(Reprinted from *The Agricultural Journal of India.*)



THE NORTH-WEST LOCUST

Proscopiinæ (American).

Tryxalinæ.—The face looking down, the vertex of the head produced forward forming an angle. Prosternum unarmed.

Oedipodinæ.—The face looking forward, vertex rounded. Prosternum unarmed.

Pyrgomorphinæ.—Face looking downwards, prosternum with an elevated lamina.

Pamphaginæ.—(Europe, Africa and E. Asia).

Acridiinæ.—Face looking forwards, prosternum with a tooth-like process.

The classification is best studied in the works of Brunner, de Saussure and Bolivar. The *Tetriginæ* are recognizable at sight; the *Acridiinæ* and *Pyrgomorphinæ* are clearly distinct, the *Tryxalinæ* and *Oedipodinæ* are not always easily distinguished as the characters are not universal in both sub-families.

Tetriginæ (*Tettigides*).—Small insects, of a dark-brown colour, found upon the soil and in grasslands. There are a considerable number of species which are not easy to distinguish. The sub-family as a whole are sharply marked off from the remainder of the family. Most are roughened and warty above, as are the *Chrotogoni*, and this with their colouring renders them difficult to see on the soil. Some are leaf-like and live among dead leaves; all are bizarre in appearance and superficially resemble Membracids. They are most abundant on damp soil and near water; some are aquatic and have the hind tarsi more or less expanded to serve for swimming; at least one species in India is aquatic, feeding on vegetation at or below the surface.

Hancock lists a total of 434 species from all parts of the world, with 34 Indian species. *Scelimena* (fig. 21) is a semi-aquatic genus with three Indian species, *S. producta*, Serv.; *S. harpago*, Serv. and *S. uncinata*, Serv. *Criotettix* has five Indian species; in this genus the insertion of the antennæ is on a level with the lower part of the eye, in the former below the eye. *Acanthalobus* has three species. *Mazarredia* is an Oriental genus with four species in India. *Paratettix* has two Indian, two Burmese species; *Coptotettix* has four Burmah species, and *Saussu-*

rella two, one also from India. The student should consult Hancock (Genera Insectorum) for the genera, Brunner and Bolivar for most of the species.

Eumastacinæ.—The species of this sub-family are not found commonly in the plains and are confined to the moister forest areas. Burr lists 23 Indian species (Genera Insectorum) including the aberrant *Chorectypus fenestratus*, Serv.

Tryxalinæ.—The genus *Tryxalis* (*Acrida*) includes a small number of very variably coloured insects, distinguished by their slender form, produced head and flattened antennæ. One species (fig. 23) is common throughout the plains, formerly known as *Tryxalis turrita*, L. ; there is confusion in the present nomenclature and it is also referred to as *Acrida turrita*, L. and as *A. exaltata*, Wlk. This species varies in colour from green to "dry grass" colour, some with bright markings, others without; the males are smaller (36-46 m.m.) than the females (52-64 m.m.). *Tryxalis lugubris*, Burr is a second large species separated by Mr. Burr in his revision of the genus (Trans. Ent. Soc. London, 1902, p. 149). *T. brevicollis*, Bol. and *T. variabilis*, Klug. are also Indian. *Acridella* is represented by *A. indica*, Bol. and *Gelastorrhinus* by two species from Burmah and Sikkim, respectively.

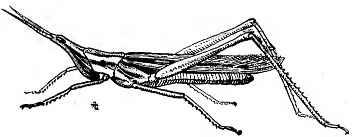
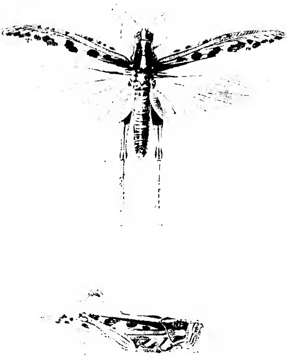


Fig. 23—TRYXALIS TURRITA.
(F. M. H.)

PLATE VI.—THE BLACK-SPOTTED GRASSHOPPER.

CYRTACANTHACRIS RANACEA (ACRIDIUM AERUGINOSUM).

(Reprinted from *The Agricultural Journal of India.*)



THE BLACK SPOTTED GRASSHOPPER.

Epacromia.—A genus of small grasshoppers, common throughout India. *E. dorsalis*, Thunb. (fig. 24) is the most abundant species, found as a surface grasshopper destructive to young crops. It has the unusual habit of coming to light. There appear to be two broods yearly during the rains and hibernation takes place in the egg stage.

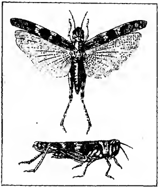


Fig. 24—EPACROMIA DORSALIS. (I. M. N.)

Oedipodinæ.—This is a large sub-family including a large number of species difficult to distinguish. *Oedaleus* (Gastromargus) *marmoratus*, Thunb. is universal in the plains, marked by its brilliant orange and black lower wing. *Sphingonotus*, *Trilophidia*, *Acrotylus*, *Heteropternis*, *Chloeobora* and *Dittopternis* are also represented. *Pachytylus* (Locusta) *cinerascens*, Fabr. (danicus, L.) is a large insect of a dull grey colour sometimes marked with brilliant green with a median keel on the pronotum. It has a wide distribution over Southern Europe and Asia and though known to form swarms and migrate in Europe, has not been recorded as a locust in India, where it is a somewhat uncommon insect. It has been found in numbers in grasslands and there is some reason to believe that, becoming abundant in extensive tracts of grasslands in the less cultivated districts, it migrates in swarms over the country. Such swarms are apparently rare and they remain in uncultivated areas, but it will probably be definitely ascertained that the swarms of green locusts occasionally seen are of this species.

Pyrgomorphinæ.—*Aularches miliaris*, Fabr. (Phymateus punctatus, F.) is the brightly coloured grasshopper found in the lower hill slopes; it is black or dark green, with roughened tegmina and thorax, with yellow spots on the tegmina, the abdomen with red bands, the prothorax and head with a broad continuous yellow band. This insect when seized emits from pores in the thorax a liquid that froths up and diffuses an unpleasant odour. The habit is a very striking one and is apt to disconcert the unwary person who does not expect it. The warning colouration of this insect is very striking and this emission of evil-smelling froth is probably a good protection. A chirping sound is produced in this species by a method unusual in the family; at the base of each tegmen and distinct from it is a small chitinous plate, the convex curved edge of which meets the concave curved edge of the median chitinous plate at the base of the tegmina (the Scutellum); the former moves in an arc so that the curved edge which is striated, rubs against the striate fixed edge of the Scutellum, producing a vibration which is probably intensified by the tegmina. The sound is distinct but not loud and is probably protective as it is produced by the female.

This is the so-called "Coffee Locust" since it occurs plentifully on coffee estates but it is practically harmless. It is recorded as destructive to coffee in Ceylon and E. E. Green has published a circular on it (Circ. Roy. Bot. Garden, Ceylon, 111, 18). There is, in Ceylon, one brood yearly, eggs being laid in October-November and hatching in March, the nymphs being full grown by September. Several species have been made of the varieties of this species.

Poecilocera picta, Fabr. is the conspicuous Painted Grasshopper so common on the ak plant (*Calotropis* spp.). It is brightly coloured in blue and yellow, living openly on its food plants and evidently protected by its bad taste from birds. There are at least two broods a year, the last (in November) laying eggs that pass through the winter. The nymph is coloured in yellow with black stipples and red spots, this colouring gradually giving place to that of the adult in the last two instars before the final moult. The distribution of this species is peculiar and follows that of its food plant which thrives in the drier portions of India from the north of the Punjab to the Southern extremity of Madras. *Atractomorpha crenulata*, Fabr. (fig. 25) is extremely common throughout the plains, and is a serious pest to young plants. The males are smaller than the females and often brown, while the female is commonly green. Tobacco is a favourite food plant of the insect in all stages and the round holes eaten in the leaves of this plant are frequently the work of this species. It is reported as injurious to cane in Java.

Chrotogonus (fig. 26) includes the common surface grasshoppers, flattened, the upper surface of a dark earth colour, roughened, with spots of white or yellow, the lower surface white. These insects are found in fallow fields, on newly-sown land, in grass and low crops. The male is smaller than the female. The latter lays about 60 eggs in a mass in the soil and there appear to be no regular seasons for breeding. They are among the most common of insects in the cultivated plains and are often seriously destructive. The number of species concerned is very uncertain. *Chrotogonus trachypterus*, Bl. appears to be the common plains' species but it is either a variable species or several are confused. *C. lugubris*, Bl. is a smaller insect of similar appearance. (See Ann. Soc. Ent., France, V, 607, where Blanchard describes *Ommexecha trachypterus, lugubris*, etc., from India.)

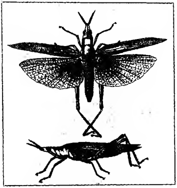


Fig. 25—ATRACTOMORPHA CRENULATA.

Acridiinæ.—A large sub-family which includes the locusts and large grasshoppers. They are readily recognised by the tooth between the base of the forelegs.

Catantops is a large genus of moderate sized insects found commonly

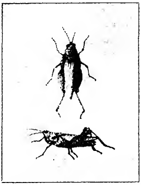


Fig. 26—CHROTOGONUS LUGUBRIS. (I. M. N.)

in grass lands. *C. indicus*, Bol., *C. humeralis*, Thunb. and *C. axillaris*, Thunb. are the species of general occurrence. *Cyrtacanthacris ranacea*, Stoll. (*Acridium aeruginosum*, Burm.) is the very common large grasshopper found in the fields especially on cotton. There is no record of its migrating. It breeds apparently at all times, the eggs as usual in the ground, the nymphs being green, a pinkish line developing on the posterior edge of the pronotum as development proceeds. In the insectary eggs were laid in November, hatched in January, and, after six moults the nymphs became full grown in May, the total nymphal life being 113 to 138 days. They were fed wholly on cotton. Males are smaller than females. The adult is distinctly more markedly black and white in colouring than any common Indian *Acridium* (Plate VI). *Schistocerca* (*Acridium*) *peregrinum*, Ol. is the North-West or Migratory Locust of greatest notoriety (Plate V). It occurs now over North India, Afghanistan, Arabia, Persia, Northern Africa and Cyprus; it has been found far out in the Atlantic Ocean and is believed to have actually originated in South America and spread thence to Africa; it is known to have spread so far West as England and constantly reaches the Assam valley and the most Eastern Hills of Northern India. It has been much discussed and written about, but we are not aware of any one really good account of its life history, depredations and movements. In India it is destructive only in the dry areas of the Punjab, since only in these does it breed; the swarms of adults can be frightened away, but it is the hoppers (Plate IV) which are really destructive. The student should see the article on "Locusts in India" in the Agricultural Journal of India, Vol. II, p. 238. and consult the voluminous literature on the subject. *Acridium succinctum*, Linn. (Plates II and III) has been the subject of investigation recently and while we require to know more of its enemies, its movements and life history are well known (Mem. Agric. Dept. India, Ent. I, "The Bombay Locust"). The most interesting point is the very curious colour changes which are more complex than in the Migratory Locust. The following extract is interesting as it almost certainly refers to this species :—

"A friend of Mr. Kirby informed him, that at Poona an immense cloud of locusts ravaged all the Mahratta territory, and was thought to have come from Arabia. This, indeed, was a most astonishing swarm, if Mr. Kirby's friend was correctly informed. The column extended five hundred miles, and was so dense as thoroughly to hide the sun, and prevent any object from casting a shadow. This horde was not composed of the migratory locust, but of a red species, which imparted a sanguine colour to the trees on which they settled." (Cuvier's Natural History, 1832, Vol. II, p. 207.) *Acridium* is also represented in the plains by rarer forms, large robust insects found chiefly on trees and bushes.

Demodocus (*Heteracris*) includes large grasshoppers distinct from *Acridium* in having the pronotum more flattened with two dorsal light stripes enclosing a central dark fascia. *D. robustus* and *D. capensis*, Thunb. are common species.

Hieroglyphus banian, Fabr. (furcifer, Serv.), is known as the Rice Grasshopper and breeds freely in rice land and wet grassland (Plate VII). There is but one brood yearly, the eggs remaining in the soil from November to June. The tendency to abbreviation of the wings is very marked and in the same place can be found macropterous forms with intermediates to micropterous ones. There is a considerable amount of variation in size and a species (*H. cotesii*) was described which is probably not valid. The common species can be found over a wide area of the moister parts of India. Amongst the most delightful of Indian

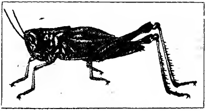


Fig. 27—HIEROGLYPHUS FURCIFER, MICROPTEROUS FORM.

insects is the large *Teratodus monticollis*, Gr. (fig. 28); it is dull green or "dry grass" colour, with brighser colouring under the wings; the pronotum is produced up as a sharp hood over the body, giving it a most striking appearance; in flight (fig. 29) it is extremely beautiful, the bright colours showing out. While it is common in Western and Southern India, it does not appear to occur East of the Deccan and the dry parts of Central India. The young forms have the hood well developed and are extremely striking in appearance, the lateral compression being very marked. They look like green leaves.

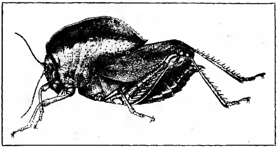


Fig. 28—TERATODUS MONTICOLLIS.

In thick vegetation and in green crops, one sees numbers of little active green grasshoppers, feeding on leaves and often very destructive; these are *Oxya*, the common species known as *O. velox*, Thunb. predominating; these are of small size, and have a dark streak along each side and on to the tegmen. They are found commonly in the rains and appear to emerge only at that time.

Collecting, etc.—Grasshoppers are easily collected, either with a net or by hand. Many forms are got by sweeping in vegetation and this is perhaps the best method. Few come to lights (*Epacromia, Chrotogonus*, etc.) or to any bait that can be put down. When killed in a cyanide bottle they make good specimens; benzene, chloroform and other fluids are not good, the hind legs being often shed or broken. They are easily stored in paper cylinders and travel well through the post in this way: if pinned, the left wings should be spread, the pin through the right wing or thorax. Large specimens may be stuffed, but this is not necessary if the specimen is properly dried. Rearing from the egg is sometimes difficult unless done on a really large scale and even then the right conditions must be maintained, especially an adequate amount of moisture in the air. Adults mate in large cages and lay eggs freely if not disturbed and given suitable conditions.

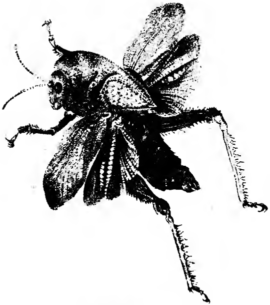


Fig. 29.—TERATODUS MONTICOLLIS.
(*From Cuvier.*)

DECEPTIVE COLOURING.

The *Acridiidæ* more than any other group of insects exhibit that combination of colours which is designated under the above term, a scheme of colouring designed to deceive birds and other predators which pursue these insects. The essential features are a cryptic scheme of colouring functional when the insect is at rest, with bright and conspicuous colouring revealed only when the insect is in flight and concealed by the forewings or by the attitude when the insect alights. If one goes into a grass field, intent on observing large grasshoppers, one will suddenly see a brightly coloured insect jump up, fly a little distance and disappear. One sees it by the bright colours and one can, as a rule, easily follow its flight by them. These bright colours are in the lower wing and perhaps part of the abdomen; they are visible only when the forewings are expanded in flight revealing the large expanse of lower wing and the abdomen. The insect in flight is easily visible owing to these bright colours and the *Acridiids* fly with a swift jerky motion, at the end of the flight suddenly wheeling down and settling motionless with closed wings. The eye has followed the bright colours and loses the insect as these disappear with the closing of the wings at the completion of the flight. One's eye is not seeking the cryptically coloured grasshopper, which thus escapes attention, even if one could easily see the motionless insect coloured in shades approximating to its surroundings and marked with darker colours to suggest the light and shade in the vegetation. With the exception of the warningly coloured grasshoppers and the vividly coloured locusts, deceptive colouration of this kind, depending upon bands of yellow, red or other vivid tints, is very common among *Acridiids*. Exceptionally beautiful examples are found in *Gastromargus* (*Oedaleus*) and in the extremely striking *Teratodus monticollis*, the colouring in the latter being on the body under the wings rather than on the wings. An instance is also found in the Leaf butterflies (*Kallima inachis*, and *K. Horsfieldi*) in which the upper surface of the wing has a bright orange blotch, visible in flight, whilst the form of the wings, the colouration and the resting attitude are extraordinarily like a leaf; at rest the insect is invisible, in flight it is conspicuous and the transition from the latter to the former at the close of a brief zigzag flight is extraordinarily deceptive.

Another group with conspicuous examples is the *Sphingidæ*, the body and forewing of the large species being commonly coloured in dull cryptic tints which harmonize with bark, while the lower wings are banded in bright colours which extend often to the sides of the basal abdominal segments. The same colouring is found, for instance, in Noctuid Moths of the genera *Ophideres*, *Ophiusa*, *Hyblaa* and *Catocala*, as well as in the *Mantidæ*, a few of the *Arctiinæ*, and an exceptional *Pyralid*. Some *Coreidae* also exhibit it and it is probably commoner in cryptically coloured insects than is generally supposed. The commoner *Cicadas* exhibit it in exceptional beauty, the cryptic colouring being very marked and the lower wing very vivid, the flight jerky and in zigzags. We are probably correct in concluding that in all these, the insect relies on its protective colouring first, but if disturbed, the deceptive colouring is brought into play in the sudden quick flight to another tree, when cryptic colouring is again predominant. This colouring gives us a glimpse into the inner life of insects which is, in its way, instructive. There are so many adaptations of this kind in insects that one can realize dimly that, always and at all times, they are in danger from birds, from lizards, from Asilid flies, from Dragon flies, from Locustids, from Mantids and so on. To enable them to escape they have various forms of colouring but the mere fact that they are in constant danger of being destroyed shows how far their mentality must differ from ours and how constant is the working of that balance of life that prevents the undue increase of any one species above its fellows.

LOCUSTIDÆ.—*Long-horned Grasshoppers.*

The antennæ long, many-jointed. The auditory organ on the fore tibia. Tarsi four-jointed. The female with a conspicuous ovipositor.

This family is at once distinguishable from the *Acridiids* by the long antennæ and the position of the auditory organ; it is less clearly dis-

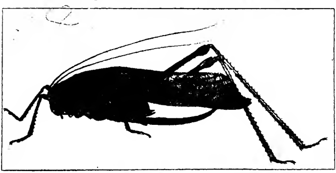


FIG. 30—MECOPODA ELONGATA.

tinct from *Gryllids* in the wings and tarsi. These insects are usually of large size, none of less than half an inch in length, a few exceeding two inches. They are less robustly built than the *Acridiids* and include a greater variety of forms. Many are elongate, the body narrow, the general colour green variegated with darker tints, their form and colour blending with the grass or vegetation among which they live. Others are larger, the tegmina broader and leaf-like; (fig. 31) the colour is green and the veins of the tegmina suggest the veins on a green leaf. These live upon bushy plants and are well concealed. Others living upon bark are grey, the tegmina roughened, and so closely adapted are they to their habitat that they can scarcely be seen until they are in motion.

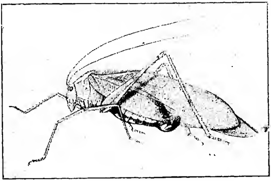


Fig. 31 – HOLOCHLORA ALBIDA.

The antennæ are very long and fine, with many joints, functioning as delicate organs of touch. The mouthparts are of the herbivorous type, the mandibles short and powerful, the palpi well developed. The prothorax is large and distinct; the tegmina are thickened and coloured. usually sloping over the abdomen, with a small basal flat area. In the males, this flat area is modified to form a sound producing organ ; the right tegmen overlaps the left and has on its lower surface a sharp point; the left on its upper surface a file ; by the movement of the tegmina, vibration is produced, the sound being intensified by the stiff tegmina. In some species this organ occurs in both sexes. The hind wings are large and folded below the tegmina. A number of species are wingless or have wings reduced in size. The foreleg has a swelling on the tibia, in which is situated the auditory organ, closed externally by a tympanal membrane situated in a small depression. This organ is not present in all species. The hind leg is similar to that of the *Acridiids*, the femur dilated near the base, the tibia long and reaching to the base of the femur. The female is characterised by the ovipositor, a conspicuous external structure, often of large size and shaped like a sword. The male has external elasping organs. The abdomen is soft and fleshy, not extensible.

The life history of no Indian species appears to have been worked out, though the eggs and nymphs are common. Eggs are laid in the edges of leaves, in the stems of grasses, in the bark of trees and in the soil. As a rule these eggs are flattened; the female makes a slit with the ovipositor and deposits her eggs in the slit. Nymphs are found in the habitat of the adults and pass through an unknown number of moults, the wings appearing gradually.

Locustids are, as a rule, nocturnal in habit. remaining quietly in concealment during the day; this is not an invariable rule. While many are herbivorous, some are predaceous on insects, probably only in part and with the power of becoming herbivorous if food is scarce. The holes eaten in the blades of leaves of ornamental shrubs in the plains are probably the work wholly of *Locustidæ* and a large proportion appear to feed in this way. Diurnal species have been seen to capture butterflies, but as most are nocturnal their food is not known. Many are conspicuous songsters, the sounds produced varying from a deep harsh note to a sustained high shrill one. Some come to light, as do so many winged nocturnal insects. *Locustidæ* are most abundant in the rainy months and are practically never captured during the cold weather where this is well marked. Hibernation appears to take place in the egg stage but this is not certain and if it occurs, the eggs must presumably be laid in some situation more permanent than a grass stem or a leaf.

In India none are recorded as pests except the aberrant burrowing *Schizodactylus* whose habits place it among *Gryllids* rather than *Locustids*. Elsewhere are few which become sufficiently abundant to be destructive to cultivated plants. These insects are rarely found in numbers in India and appear to increase slowly. The *Conocephali* that live in grass are perhaps the most abundant.

The most recent catalogue of the family is Kirby's in Volume II of "Synonymic Catalogue of the Orthoptera" (1907). Following Brunner he divides the family into 24 sub-families half of which are unknown in "India" or known from single genera only, while four only contain the majority of our species. A total of 205 species is enumerated from India, Burmah and Ceylon, though the family is extremely little known in India and many species remain to be found. In this as in other Orthopterous families, the number of tropical forms far exceeds the Himalayan and palæarctic, though in this family more than others the vast majority are forest species and are found but rarely in the cultivated plains. The literature of Indian forms is given by Kirby; the works of Brunner, Bolivar, Redtenbacher, Saussure are the most important. The distribution of species is as follows:—*Stenopelmatinæ* 5, *Rhaphidophorinæ* 3, *Gryllacrinæ* 40, *Decticinæ* 1, *Scyinæ* 1, *Conocephalinæ* 13, *Agræciinæ* 10, *Xiphidiinæ* 8, *Listrocebinæ* 6, *Eumegalodontinæ* 1, *Prophalangopsinæ* 1, *Pseudophyllinæ* 45, *Mecophodinæ* 2, *Phyllophorinæ* 7, *Phaneropterinæ* 57.

Stenopelmatinæ. *Oryctopus* includes two species found in burrows in a river bank near Trichinopoly by the Professors of St. Joseph's College. The male has rudiments of tegmina and wings, well developed eyes and tarsal claws; the female has quite small eye spots, the antennæ are very small or absent, the tarsal claws rudimentary, the ovipositor absent and the insect is wholly apterous. Both sexes were found together in the burrow. Two species are described, *O. Bolivari*, Brunn. and *O. prodigiosus*, Bol. (fig. 32). We figure the female from Bolivar (Ann. Soc. Ent. France, 1899, 784).

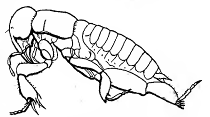


Fig. 32—ORYCTOPUS PRODIGIOSUS, FEMALE. × 2. (*After Bolivar.*)

Gryllacrinæ. Schizodactylus monstruosus, Don. (fig. 33) (the bhерwa of Behar) is an extraordinary insect, rather doubtfully placed in this family. It is a large insect, robustly built, with long tegmina which roll up into a spiral; the sides of the tegmina turn down abruptly as in the *Gryllidæ* and the tarsi have curious flat expansions. The appearance of the insect is extremely striking and its large jaws make it appear ferocious. It is wholly a burrowing insect, living in sandy soil and often near rivers, making deep burrows in which it lives. The eggs are laid in the burrow, the female having no ovipositor and behaving much like a cricket. It is believed to be carnivorous, and is destructive to crops only when its borrows are so abundant that it cuts the roots of plants. Its distribution in India is a curious one including Tirhoot, parts of Assam, Bellary, parts of Sind and Multan. Apparently it is dependent upon peculiar conditions of soil and moisture.

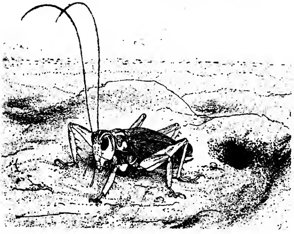


Fig. 33—SCHIZODACTYLUS MONSTRUOSUS.
(F. M. H.)

Conocephalinae.—*Conocephalus* includes narrow grasshopper-like forms which live in grass. Their eggs are laid in the stems of grasses

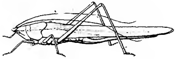


Fig. 34—CONOCEPHALUS INDICUS REDT.

and the insects of all ages are found in waste lands and long grass. The males produce a sustained shrill note which is exceedingly difficult to locate and the shrill music heard in long grass is mainly produced by these species. *C. indicus*, Redt. and *C. pallidus*, Redt. are the common species.

Mecopodinae.—*Mecopoda elongata* (fig. 30) is a very large form, of a dark brown colour, of the " dead-leaf " tint, the tegmina often with markings such as are found on decaying leaves; it is found sparsely over the plains, among trees and not in the open. "

Pseudophyllinae.—*Sathrophyllia* includes the large flattened forms coloured like bark, which are found sitting motionless on the bark of trees by day and are active by night. Their roughened upper surface, their colouring in dull shades of brown and grey, their flattened form and motionless attitude pressed against the bark renders them a very notable case of cryptic form and colouring and they are extremely difficult to see.

Collecting.—Locustids are best collected by careful search among grass, on bushes, on the bark of trees, under the loose sheets of bark that are found on some trees and between the sheathing leaf-stalks of palms. Rearing is apparently possible only when the food habits of the young are first ascertained. When killed (in a cyanide or B. C. bottle), they should be pinned through the right tegmen, the left tegmen and wings set. Drying must be very thorough as the abdomen is very fleshy, but if properly done, stuffing the abdomen with carbolised cotton or other similar treatment is not required.

GRYLLIDÆ.—*Crickets.*

Leaping insects, with usually long filiform antennæ. The auditory organ is on the fore tibia. The wings are turned over at right angles from the dorsal to the lateral surface of the body. Tarsi three-jointed; female with a long ovipositor.

Gryllidæ are distinct from *Locustidæ* in the tarsi and the wings; they are, however, a group which contain many different types of insects which hardly fall into one family and which, with further knowledge, will probably be split up. All do not have long antennæ; some have no ovipositor, and in others the wings are not deflexed. If we remember *Schizodactylus* which may be a Gryllid, and are familiar with *Gryllotalpa* and *Tridactylus*, it is easy to realise that *Locustidæ* and *Gryllidæ* are hard to separate and that peculiar environment has produced such changes in some forms that they scarcely come within the definition of the family. The *Gryllidæ* as a whole are a large family not of great importance economically and not interesting to the ordinary student of nature. The Indian species are probably very imperfectly known. Brunner lists 43 species from Burmah of which he describes 20 as new to science; Bolivar lists 35 from South India of which 14 were new. Kirby's Catalogue lists 130 species from India, Burmah and Ceylon of which 80 occur in India. There are probably many new species to be found and there is much interesting work to be done in the biology of all of them. The works of Saussure, Brunner van Wattenwyl and Bolivar include the most important literature of the family as a whole.

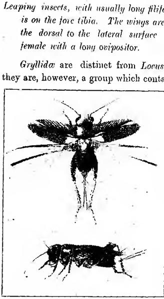


Fig. 35—LIOGRYLLUS BIMACULATUS. (I. M. N.)

Allowing them to be a group which will eventually be split up and are now maintained for convenience rather than logical fact we can discuss them individually and need make no general statements about the family as a whole. The family is by de Saussure divided into seven tribes, regarded by Kirby as six sub-families. The following key follows de Saussure's arrangement and is given in Sharp's Insects :—

1. Antennæ ten-jointed : posterior tarsi aborted. Tribe 1. *Tridactylides.*

1'. Antennæ many jointed ; posterior tarsi normal.

2. Tarsi compressed, the second joint minute.

3. Anterior legs fossorial ; anterior tibiæ at the apex with two to four divisions. Pronotum elongate, ovate, rounded behind. Female without ovipositor. Tribe 2. *Gryllotalpides.*

3'. Anterior legs formed for walking. Ovipositor of the female visible (either elongate or rudimentary).

4. Posterior tibiæ biseriately serrate. Tribe 3. *Myrmecophilides.*

4'. Posterior tibiæ biseriately spinose. Ovipositor straight.

5. Antennæ short, thickish, almost thread-like. Facial scutellum exserted between antennæ. Posterior tibiæ dilated. Gen. *Myrmecophila.**

5'. Antennæ elongate, setaceous. Facial scutellum transverse, visible below the antennæ. Tibiæ slender.

6. Posterior tibiæ armed with two strong spines, not serrate between the spines. Tribe 4. *Gryllides.*

6'. Posterior tibiæ slender, armed with slender spines, and serrate between them. Tribe 5. *Oecanthides.*

2'. Second joint of the tarsi depressed, heart-shaped.

3. Posterior tibiæ not serrate, but biseriately spinose.

4. The spines on each side three and mobile ; apical spurs on the inner side only two in number. Ovipositor short, curved. Tribe 6. *Trigonidiides.*

4'. The spines numerous, fixed. Ovipositor elongate, straight. Gen. *Stenogryllus.*

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* The genus *Myrmecophila*, being exceptional in several respects, is treated separately.

3'. Posterior tibiæ serrate and spinose on each side, the apical spurs, as usual, three on each side. Ovipositor straight or curved. Tribe 7. *Encopterides.*

We may here discuss the group under divisions including the *Tridactylinæ* (small surface crickets), *Gryllotalpinæ* (mole crickets), *Gryllinæ* (house and field crickets, burrowing crickets), *Oecanthinæ* (plant crickets).

Tridactylinæ are small insects, measuring about one-quarter of an inch in length; the antennæ are short with about ten joints, the wings in some are imperfectly developed, in some fully developed: the abdomen terminates in six processes like cerci, which are hairy and strongly suggest the hairy processes used by some aquatic larvæ to support themselves on the surface film of water while they get air. The hind legs terminate in two straight processes, the tarsus not being formed, and the tibia also bears lateral processes, which apparently are spread out upon the wet soil on which the insect lives and act as supports; these lateral processes are also capable of being closed up. These little insects live upon damp soil; they are common on the banks of tanks, in irrigated fields, in watered gardens; they prepare small galleries by burrowing along the surface of the soil and live in these burrows. They form a very large part of the tiny "flies" which crowd in hordes round lamps in such places as Calcutta and are enormously abundant in places near large rivers. *Tridactylus variegatus*, Latr. in Europe is said to burrow in the sand of river banks. *Tridactylus thoracicus*, Guer. from the Nilgiris, *T. major*, Scudd. from "India" and *T. castetsi*, Bol. from Trichinopoly are our recorded species.

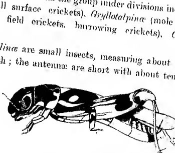

Fig. 36—TRIDACTYLUS SP. × 8.

Gryllotalpinæ include large insects, which are characterised readily by the forelegs, which are profoundly modified to form powerful digging instruments. These insects grow to a length of over one inch, the head and prothorax very hard, the antennæ short, the wings tightly wrapped round the soft abdomen (fig. 37). As in other Gryllids, the hind wings are extended backwards and appear as a slender process beyond the tegmina when at rest. There is a pair of cerci at the end of the abdomen. The forelegs are extremely powerful and by digging and pressing, the hard head and prothorax is forced through the soil, the soft abdomen and weaker posterior legs following. The female is destitute of an ovipositor and lays her eggs (fig. 38) in the burrow, which extends to a considerable depth below the surface. These eggs have been found in a cluster in the moist sand of the river bank, soft white oval eggs lying loosely in a round chamber at some depth in the sand. The young

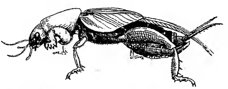

Fig. 37—GRYLLOTALPA AFRICANA. × 2.

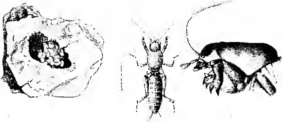

Fig. 38—GRYLLOTALPA AFRICANA; EGGS, REDUCED TO $\frac{3}{4}$, AND NYMPH.

nymphs thrive on a diet of fly grubs, worms and other small animal life, making small burrows in the loose sand.

Like other parts of the earth's surface, the soil for some twenty feet down contains abundant insect and other life, which forms the food of the mole cricket and in search of which it burrows through the soil. When its burrows are near the surface, damage is caused to the roots of plants and the insect is destructive to this extent.

The winged imago flies at night and comes to light very readily. In the rains they are often flooded out and in dry weather descend deeper for soil moisture. There are many ingenious ways of destroying them, none sufficiently effective to appeal to any but an economic entomologist. Two species occur in India, *Gryllotalpa africana*, Pal. B., which is widespread over the plains and lower hills (also through the warmer parts of Asia and Europe), and *G. vulgaris*, Latr., found in the Himalayas and common also in Europe, Egypt, Western Asia, etc. Throughout our area, *africana* alone appears to occur.

The *Myrmecophilinæ* are small insects chiefly interesting because they are found in ant's nests. A variety of *Myrmecophila acervorum*,

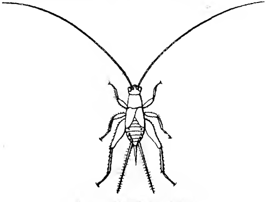

FIG. 39 PTEROPLISTUS PLATYCLEIS.
(*After Bolivar.*)

Panz., was found by Wroughton, *M. plagiolepidis* Wasm. by Assmuth, while *Ornebius Guerini*, Bol., and *O. nigripalpis*, Guer., and *Pteroplistus platycleis*, Bol., are recorded from South India and several from Burmah. (See below under *Myrmecophilous Insects* after *Paussidæ*.)

We come then to the *Gryllinæ*, the "crickets." These insects are distinguished from *Locustides* by the characters given at the head of the section. They vary in size from half an inch to over two inches in length; the colours are dull, mainly cryptic, brown predominating with black and rarely yellow-brown. None are brilliant or conspicuous, and the colouring is that of other surface-living insects. The antennæ are long and filiform; head large, the prothorax distinct. The tegmina are deflexed, the inner area lying flat on the upper surface, the outer area vertically against the side of the body. The lower wings are produced back and when at rest, give the appearance of a projecting sting or process. At the apex of the abdomen are two cerci, and as the female has a long fine ovipositor, the hind end of a female cricket bristles with formidable looking structures. Auditory organs are situate in the foreleg, as in the Locustidæ.

Gryllidæ produce loud and sustained sounds, often very shrill, by the rapid vibration of the wings, one (right) working over the other (left), the edge of the one acting on the file on the other. The males have the flat area of the tegmina modified to intensify the sound, though to a less extent than is the case in Locustidæ. The sound is peculiarly shrill and sustained, extremely difficult to locate in the field. Some of the smaller species may be seen to be vibrating their wings but the sound produced is not audible to everyone, the pitch being so high it is beyond the register of the normal human ear. Apterous forms also occur and species in which the wings are reduced in size. Almost nothing is known of the life history of Indian crickets. The young are similar in general appearance to the adults, but the number of moults is not known.

There are practically three distinct classes of crickets. Some burrow deeply in the soil, making very extensive burrows which have several openings at the surface. Others live on the surface, among fallen leaves and other debris and make short burrows into which to retire but do not habitually live concealed in them. Of these a few are household insects. Others live on plants, passing their life among bushy vegetation

The burrowing species are vegetarian feeding upon roots and also coming up at night to cut off green vegetation. Little is known of the food of other species. The small bush crickets are to some extent predaceous on small insects and there is no reason to believe they are vegetarian. The surface-living species are possibly also predaceous but one at least is found feeding upon living plants. Crickets are universally distributed in India and are perhaps as abundant in the drier plain areas as in the moist tracts of the delta and forest districts.

The large brown cricket (*Brachytrypes achatinus*, Stoll.), is the most familiar burrowing species, found commonly in the Himalayas and the adjacent plains, in Assam and Burma. It has a wide distribution in Eastern Asia and may be widely distributed in suitable localities throughout the plains. It grows to a large size and is rarely seen on the surface save when the heavy rains flood it out from its burrows. At dusk, the male comes to the surface, and pours forth its strident note, the sustained shrill vibration being very piercing and, as one approaches, beating in the ears with extraordinary intensity; even a *Cicada* hardly produces such intensity of sound. At night the cricket seeks its food, the leaves

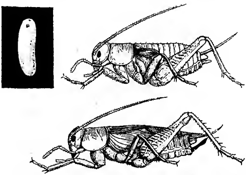

Fig. 40—BRACHYTRYPES ACHATINUS. EGG × 4. NYMPH, FOURTH INSTAR × 1½. IMAGO. × 1.

and shoots of plants which it eats or draws into its burrow. The life history occupies one year, the winged adults being found from late April to September, only nymphs being found in the cold weather. It has been successfully reared in the Pusa insectary on a diet of green lucerne and other plants. This species is the prey of *Sphex lobatus* the metallic green digger wasp (see *Sphegidæ*). *Liogryllus bimaculatus*, deG. is black, with an orange spot at the base of each tegmen. It appears to occur throughout India, and is stated to be found throughout the East. It has been found in Khandesh to cut through the stems of potato plants at soil level. (Ind. Mus. Notes, Vol. III, p. 97.)

Gryllodes melanocephalus, Serv. (fig. 41) is reported as injurious to crops and has been found in some number in parts of the Punjab. It is a surface-burrowing species, living in the fields and not making deep burrows. There are a large number of species to be found in the plains and an investigation of the Indian species is much to be desired.

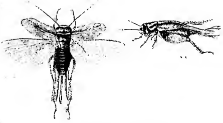

Fig. 41—GRYLLODES MELANOCEPHALUS.
(I. M. N.)

Kirby (Synonymic Catalogue of Orthoptera, Vol. II, 1906), records *Paranemobius* 1, *Nemobius* 4, *Brachytrypes* 3, *Gymnogryllus* 3, *Gryllus* 12, *Gryllodes* 6, *Cophogryllus* 2, *Scapsipedus* 2, *Homaloblemmus* 1, *Loxoblemmus* 1, *Landrena* 1, as genera represented in India, apart from Himalaya, Ceylon and Burmah.

The *Oecanthinæ* are represented by *Oecanthus indicus* Sauss., a delicate whitish insect with a tinge of pellucid green. It has the general characters of *Gryllids* but is easily recognisable. This insect is found upon plants, in rice fields and in dense moist vegetation. Its life history does not appear to have been worked out in India. It is, to some extent at least, predaceous and has been observed eating insects it has captured in the field. Other recorded Indian species are *Arachnomimus picticeps*, Wlk., *A. dubius*, Bol., and *Oecanthus rufescens*, Serv.

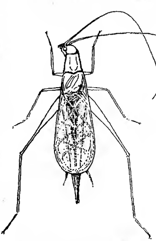
Fig. 42—OECANTHUS INDICUS. × 3.

The *Trigonidiinæ* are but little known and only five species are recorded from India proper: these are *Trigonidium cicindeloides*, Ramb., *T. gigas*, Bol., *Cyrtoxipha* (Eneoptera) *fascipes*, Wlk., *C. concolor*, Wlk., and *C. alboatra*, Wlk.

The *Eneopterinæ* include *Madasumma* (7 spp.) as well as *Patiscus quadripunctatus*, Bol., *Corixogryllus abbreviatus*, Bol., and *Meloimorpha cincticornis*, Wlk.

Collecting.—A knowledge of their habitat is the surest guide to the methods of obtaining crickets of all kinds. Tridactylides are readily found in moist places, and also at light: Gryllotalpa comes to light and may be dug out: the Gryllides can be dug out, found among fallen vegetation, or caught in the evening when they emerge; some come to light and some are flooded out in the rains. Oecanthides are found upon plants and are best looked for when sweeping pests in rice.

The lesser forms are very little known, on account of their fragility, and the number of undescribed forms is probably very large: equally little is known of their habits or life-histories and there is room here for a very extended investigation by an observer situated in the plains. where these little insects abound.

ATTRACTION TO LIGHT.

Among the many methods adopted by Entomologists to obtain insects in number, the light trap is one of the simplest and most efficacious. In India, the attraction of insects to light is so disagreeably and abundantly proved, that it is familiar to every one, though there is little exact information as to which insects come to light. The real difficulty is not to get the insects to come to light but to catch them in good condition when they come.

Generally speaking, a little is known as to the groups that are attracted by light and some careful collecting at light for a few years would soon furnish the data necessary to list the light-loving species.

A curious point is the kind of light; the intense white of an arc light brings insects in hordes as can be seen on Howrah bridge or on a river steamer; the same is true of the acetylene light, a very white intense light; the yellower oil light may attract fewer insects because of its less range but this is by no means certain. Whether coloured lights exert the same influence, and which colours are best would appear to be a promising line of research, especially in relation to injurious insects as one might then be able to discriminate the harmful and not destroy the harmless. Actually no experiments on this point seem to have been made in this country and our data refer to white light entirely.

A consideration of the insects that are known to come to light in any country, has not, so far as we are aware, led to any facts concerning the nature of the attraction light exerts: Crepuscular or Nocturnal insects are not attracted as a body, though naturally nearly all that are attracted to light are insects that are active after daylight. Only flying insects are known to be attracted, but so far as we are aware all experiments have been made with a light elevated above the ground and without means of trapping walking insects. A considerable proportion that come are ground insects, such as the Ground beetles, but the proportion is only what one would expect when one considers how large is this part of the fauna. The principal families found at white light in India are mentioned below but this account is a very incomplete one.

Blattids are rarely caught but some species have found their way to light traps. Of *Acridiidæ*, *Epacromia dorsalis* is a very notable example, coming abundantly to lights even into houses. A small number of other *Acridiidæ* have the same habit. *Conocephalus* among *Locustidæ*, as well as *Schizodactylus* and a few green species, are found at light. Of *Gryllidæ*, the burrowing mole crickets, *Brachytrypes*, *Gryllus*, *Nemobius* and other *Gryllinæ*, are attracted; the little *Tridactylinæ* come in hordes to lamps and are extraordinarily abundant at some seasons even at a feeble railway station lamp. *Embiids*, winged termites and Myrmeleonids come readily; Phryganeids are conspicuous by their presence, as are *Ephemerids*, *Mantispides*, *Ascalaphides* and *Chrysopides*. Nearly all *Hymenoptera* are diurnal, but the flying ants are often caught in very large numbers at light traps and some few Parasitica. Of *Coleoptera* the nocturnal *Scarabæids*, principally *Melolonthids* and *Dynastids* with some of the *Coprids* (*Geotrupids*) are attracted, as are the *Carabidæ* (especially *Scaritides*), *Paussidæ*, *Cantharidæ*, some Malacodermids and an occasional weevil (*Asemus*).

Moths come freely, especially the *Noctuids* and *Pyralids*, with some *Sphingids* but not every species is attracted and the fact has to be ascertained for each species. *Cydninæ* are the only *Pentatomids* known to me to be freely attracted to light and this is possibly due to their habits: the Ganges ferry steamers are sometimes swarming with *Stibaropus*, and, as all know, the "Gundi" (*Cydnus*) is only too fond of coming to the lamp at dinner time. *Nezara viridula*, Linn., is exceptional as being attracted to light, and there are others. Aquatic *Rhynchota* are not uncommon at light and the little *Corixa hieroglyphica* is occasionally very abundant. *Cicadids* are caught at light occasionally, the giant water bug (*Belostoma*) constantly.

Of the *Fulgoridæ*, the small *Delphacinæ* come in swarms, as do the *Jassidæ*; I am not aware of other *Homoptera* though there are very likely others, and I am not acquainted with any *Diptera*, except *Chironomidæ* and *Psychodidæ*. The reader can see from the above how diverse are the insects that are attracted and what a curious selection of the nocturnal insects it is; whether there is a real physiological explanation, whether some are more curious than others, or whether some have more leisure to investigate strange phenomena, we must leave to others to decide.

The use of lights and light traps has been a favourite method with agriculturists in dealing with certain classes of pests, but it is a method of very uncertain value and it is not a method generally useful: it is essential to be certain that the pest to be captured does really come to light freely and this is a point usually neglected.

NEUROPTERA.

An assemblage of heterogeneous families, united in one order rather for convenience than scientific accuracy. There are two pairs of wings, with many veins, both functional in flight and often of equal or nearly equal size. The mouthparts are mandibulate, usually of the predaceous type. The metamorphosis is incomplete in a part, complete in the remainder, the pupa usually active at the emergence of the imago.

In a large number the nymphal or larval life is the only period of long duration and activity: in the remainder the imaginal is as long as the nymphal and of equal importance. The order includes predaceous and scavenging, land and aquatic insects. None are parasitic, and none herbivorous.

The order is here divided into ten families; grouped in series :—

No Metamorphosis.

I.—Wingless and Semiparasitic.	*Mallophaga.*—On warm-blooded animals.
II.—Land Insects. *Pseudoneuroptera.*	*Embiidæ.*—Two pairs of narrow equal wings. few veins. Prothorax small.
	Termitidæ.—Two pairs of narrow equal wings, many veined. Prothorax large. Social.
	Psocidæ.—Forewing larger than hindwing, with few cross veins. Prothorax small. Gregarious.
III.—Aquatic Insects. *Neuroptera amphibiotica.*	*Perlidæ.*—Hindwings larger than forewings, folded. Coxæ small, wide apart. Antennæ long. Cerci in some forms. Tarsi 3-jointed.
	Odonata.—Antennæ short. Two pairs of subequal wings, not folded over abdomen.
	Ephemeridæ.—Antennæ short. Two or three cerci. Hindwings small or absent. Wings held upwards.

A Metamorphosis.

IV.—Mandibles in adult. *Neuroptera Planipennia.*	*Sialidæ.* *Sialinæ.*—Antennæ long, wings not reticulate. No cerci. *Raphidiinæ.*—Prothorax long. *Panorpidæ.*—Head rostrate. *Hemerobiidæ.*—Antennæ long, wings equal, much reticulate, no cerci. Tarsi 5-jointed. *Myrmeleoninæ.*—Antennæ knobbed, short. *Ascalaphinæ.*—Antennæ knobbed, long. *Nemopterinæ.*—Hindwings long and very narrow. *Mantispinæ.*—Forelegs as in Mantidæ. *Hemerobiinæ.*—Antennæ moniliform. *Chrysopinæ.*—Antennae setiform. *Conioptergyinæ.*—Wings powdery.
V.—No Mandibles in adult. *Neuroptera Trichoptera.*	*Phryganeidæ.*—Wings hairy, an anal area to hindwing, which is longer than forewing. Coxæ long, contiguous. Tarsi 5-jointed.

The relationships of these families are obscure, and it is probably useless to attempt to derive them from any common stock. The problem is complicated by the number of aquatic families, which we may take to have been derived from terrestrial air-breathing forms. Equally the semi-parasitic *Mallophaga* are probably derived from free-living forms. It is reasonable to accept present-day *Termitidæ* as a separate branch, derived possibly from forms which were connected with the Blattid ancestors: *Embiidæ* and *Psocidæ* are off-shoots from some primitive form of Neuropteron possibly related to *Forficulidæ*. *Ephemerida* and *Odonata* are derived from insects found far back in geological times, which had probably a common ancestral race, which was terrestrial; the ***Perlidae*** are related to the *Ephemeridæ* and probably are a recent branch. *Sialidæ* and *Panorpidæ* may be branches from one stock, in which metamorphosis was developed, and from which came, far back, the ***Hemerobiidæ***. *Trichoptera* also remain and in the absence of data, it may perhaps be placed as an offshoot of the ancestral race in which metamorphosis had been developed, emerging therefore from the terrestrial ancestor of the *Planipennia*. Quite possibly this branch leads on from an ancestor of the present *Trichoptera* to the *Lepidoptera*, the ancestor of *Micropteryx* and of *Trichoptera* being the same and thus giving the point of contact.

MALLOPHAGA.—*Biting Lice.*

Small wingless insects, nearly all parasitic on birds. They have biting mouthparts and the body is flattened, the head often large and broad.

The Mallophaga or Bird-lice are sometimes confused with the *Pediculidæ* (Head-lice and body-lice). Although both are parasitic on warm-blooded animals and have somewhat the same appearance, they are quite distinct, the *Pediculidæ* being sucking insects, allied to Hemiptera, while the *Mallophaga* have well-developed biting mouthparts and never suck, living on the dry skin, scurf, and feathers of their hosts. Their relationship to other insects is doubtful, and Kellogg, who has monographed the group (Genera Insectorum Fasc. 66) reckons them as a distinct Order. Mallophaga spend their whole life on the host, and soon die when removed or when the body of the host becomes cold in death. Observations on their life-histories are for this reason difficult, and little is known except that the metamorphosis is incomplete. Kellogg puts the known species at over a thousand, and a large number of these are restricted to one definite species of bird; others are found on several different birds, but usually these birds either are accustomed to associate one with another in flocks, or belong to closely related species, though these related species may occur only in widely separated parts of the world.

Kellogg explains this curious fact by reference to the sedentary mode of life of the insects, which prevents their spreading from bird to bird except by actual contact. He supposes that the species of *Mallophaga* have remained unchanged since the remote periods when many different species of birds, (now settled in different parts of the globe and separated from their near relations,) had not yet diverged or evolved from their common ancestral species. Those ancient bird-lice which infested the ancestral bird continued to infest the ancestral bird's descendants: even though these descendants in time diverged into several distinct species, the conditions of life remained so much like what they had always been that the bird-lice have to this day retained the same specific characters which they possessed in those far-off times.

A few *Mallophaga* (about 50 known species) are found on Mammals, and they are distinguished from the bird-infesting species by having single-clawed feet; the species on birds have two claws. The mammalian hosts include most of the domestic animals, as well as others of very various kinds. Kellogg's classification into families is as follows:—I have included the names of the principal genera in each family.

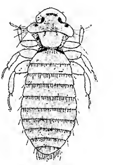

Fig. 43—COLPOCEPHALUM GUIRAENSIS (*After Kellogg*).

- Antennæ visible, 3 or 5-segmented; no maxillary palpi; mandibles vertical; meso- and meta-thorax usually fused. Sub-order *Ischnocera*.
  - Antennæ 3-segmented; tarsi with 1 claw; infesting mammals. Family *Trichodectidæ*. Genus *Trichodectes* 45 sp.
  - Antennæ 5-segmented; tarsi with 2 claws; infesting birds. Family *Philopteridæ*. Chief genera *Docophorus* 215 sp. *Nirmus* 228 sp. *Lipeurus* 181 sp.
- Antennæ concealed 4-segmented; with 4-jointed maxillary palpi; mandibles horizontal; meso-meta-thoracic suture usually visible. Sub-order *Amblycera*.
  - Tarsi with 1 claw; infesting mammals. Family *Gyropidæ*. Genus *Gyropus* 7 sp.
  - Tarsi with 2 claws; practically all infesting birds. Family *Liotheidæ*. Chief genera *Colpocephalum*, *Menopon* 211 sp.

Kellogg's list does not record any species as coming from India. (Perhaps *Trichodectes tigris*, taken from a tiger is from this country.) If, however, one takes the trouble to examine a few birds, especially at the roots of the feathers about the neck and base of the wings, it will not be long before these insects are discovered, and evidently there must be a large number of Indian species. Those named by Kellogg as having been obtained from birds belonging to species which occur in India are fourteen in number, and belong to the nine genera *Docophorus*, *Nirmus*, *Goniocotes*, *Akidoproctus*, *Goniodes*, *Ornithobius*, *Lipeurus*, *Colpocephalum*, *Menopon* and *Trinotum*.

Fig. 44 shows the egg, a young stage, and the adult of the louse of one of the big Indian buzzards (*Pernis cristatus*), and indicates how slight is the difference between the young and the full-grown parasite. The eggs are found firmly attached to the feathers of the bird. Fowls or other domesticated birds, if infested with lice, can be rid of them by carefully brushing any non-irritant vegetable oil (not paraffin or crude oil) on the skin and about the roots of the feathers. The oil stops up the breathing-spiracles and suffocates the insects. This treatment is also effective for clearing fowls or other animals of ticks. (F. M. H.)

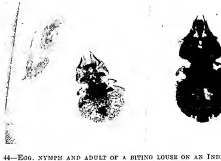

Fig. 44—Egg, nymph and adult of a biting louse on an Indian buzzard (Pernis cristatus). Magnified.

Embiidæ.

Narrow delicate insects, the prothorax small, the wings, when present, with few veins.

These little insects have an extremely characteristic appearance due to the elongate body, the short legs, the small abdominal cerci, and (in the males) especially the narrow, usually dark coloured, wings. They are black or dull-coloured, small and very delicate. The antennæ are well developed, the mouthparts are of the biting type; the prothorax is small, the tarsi three-jointed, and there is, in the male, an asymmetry of the cerci. The insects are suggestive of a primitive condition, especially in the thorax, the wings attached to segments that are in no way fused or adapted to the purposes of flight.

Very little is known of such fragile insects. The males are common at lights and are often found in houses. In the field, they are found on the surface of the ground, usually under stones or in some damp sheltered locality. They have been seen to prepare webs from threads which are produced by glands in the forefeet. This is a remarkable circumstance and very different from the methods of silk production general in the insect world.

The nature of the food is unknown, but as the insects are rare and very few, they are not of economic importance, and while of interest to the naturalist, are not likely to be found except at a lamp indoors by any but a skilled observer in the field.

One species (*Oligotoma michaeli* Macl.) has been found in London and is believed to have been imported with orchids from India. Another species (*O. saundersi*, Westw.) (fig. 45) is described from Bengal (Trans. Linn. Soc., XVII, 337).

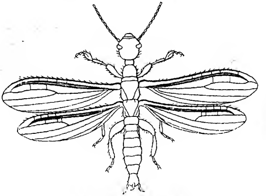

Fig. 45—OLIGOTOMA SAUNDERSI.
(*After Westwood.*)

J. Wood-Mason in 1883 (Proc. Zool. Soc., 1883, p. 328) described and figured Indian Embiides and recounts the capture of nymphs and females. The female he describes as wingless, shining black and more firmly chitinized than are the males. Males, as he remarks, are common at light, *Oligotoma saundersi*, Westw., being the common species. The nymphs he found gregarious under bricks and he figures the asymmetric male appendages.

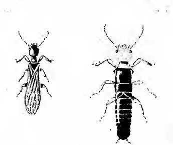
Fig. 46—Oligotoma saundersi, male (left). Oligotoma sp., female (right). × 4.

We have found colonies of these delicate little insects in the shelter of the long dry culm-sheaths of the Giant Bamboo (*Bambusa arundinacea*), as also under bricks on the soil and in decaying leaves. They live in tubes of fine white silken material, which ramify over the sheath; we were unable to find any except where the sheath had been extensively bored by a minute Scolytid and in captivity they refused to make tubes or to remain alive except on such sheaths: whether they fed on the dust produced by the Scolytid or on some other material could not be ascertained; the quite small insects are white, and very active, running quickly along the tunnels and with equal facility backwards or forwards: on seeing them scurrying backwards along the tube one is led to think that the anal cerci serve as the antennæ do when the insect is running forwards. The half-grown nymph has a reddish head, the body whitish and soft. The student should consult Hagen's monograph of the group published in the Canadian Entomologist, Vol. XVIII (1885), wherein 17 species are discussed. *Embia Brahmina*, Sss., was described in 1896 from Bombay (Mt. Schweiz. Ent. Ges., IX, p. 352), and *E. Latreillei*, Ramb., in 1842 from Bombay, Mauritius and Madagascar (Neuroptéres, p. 312).

TERMITIDÆ.—*Termites.*

Four large wings, in repose lying flat on the dorsum; three free thoracic segments. Anal cerci are present. Social, with marked polymorphism of asexual individuals.

These little insects are familiar chiefly from their depredations and are practically never seen except in the winged form, unless looked for. They are clearly distinct from all other *Neuroptera* by their habits, and from social *Hymenoptera* by their structure. The antennæ are short and straight. The segments of the thorax are distinct, the abdomen moderately large with a pair of cerci. The legs are formed for running, the mouthparts for biting. The colour of nearly all is the dull white of insects which live always in concealment, and the integument is correspondingly soft: only in those winged individuals which emerge to the air is the skin hardened and the usual colour of such insects is a deep chestnut brown.

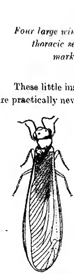

Fig. 47—TERMES OBESUS, WINGED FORM. × 2.

The most striking feature of the termites is the great development of the social system. The nest is peopled and managed by the tiny workers, small insects, sexually immature, which are active and do the necessary work of the nest; there are also a number of similarly sexless individuals, usually with larger heads and more prominent jaws, whose function apparently is the defence of the nest and the overseeing of the work of the nest carried on by the workers. As neither of these castes can usually reproduce, a limited number of sexual individuals are maintained, namely a wingless mature and fertilised queen, a wingless mature male, reserve immature queens and males. These suffice for the peopling of the nest and the establishment of new nests is provided for by the production of large numbers of winged males and females at a special season of the year.

The conduct of the nest apparently rests with the workers, who feed the whole community and who regulate the supply of each class of individuals. The queen is a helpless individual, whose sole function is the production of eggs; she lives in the nest and is usually an immensely developed creature with great egg-producing capacities: to provide for fertilised eggs a male is kept. In reserve are immature males and females which can be brought on when desired. The perplexing problem is how so many individuals are produced from one kind of egg. We meet with the same problem in ants and bees, and undoubtedly there is significance in the fact that in both cases the food is "artificial," it is food prepared by the workers and whose composition can be varied; probably they administer different kinds of food to the larvæ according as they want a particular kind of individual. The food of the whole nest consists of vegetable fibre, chewed up by the workers and partially digested; in one species it is stated to be regurgitated from the anterior part of the alimentary canal or excreted from the posterior part and is apparently in both cases used for food, which probably has very different degrees of nutritive value.

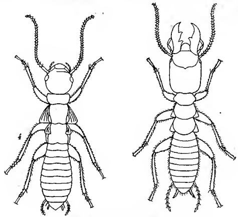
Fig. 48—TERMOPSIS WROUGHTONI MALE AND SOLDIER; × 8.
(*From Desneux.*)

It is a most striking thing to consider that the control of the whole system of development is in the hands of the lowest of all, the workers, and to the philosopher, the social system compares favourably with the pitch of development reached by the human race. New nests are provided for very simply. At certain seasons, immense numbers of winged males and females emerge. They are clumsy insects, and fly badly. They rise in a cloud and are at once attacked by innumerable birds and enemies. Those that escape shed their wings at the suture and couple. They then get into shelter and start a new nest if possible; the female lays eggs, the eggs hatch to workers and the new nest starts. In spite of the immense numbers produced, few such females escape to found nests. The emergence of these sexual winged individuals is constantly observed during the rainy months, and appears to occur after heavy rain when the air is still. A small opening is made in the surface of the soil and immense numbers of the winged insects pour out, crowding one after the other. As they emerge they attempt to fly and flutter upwards in a cloud, a phenomenon very quickly observed and one which attracts the attention of birds. Many cannot fly on emergence but run on the soil first and these are the prey of ants which at once carry them off living. The phenomenon strikes one as curiously interesting, the immense number of individuals pouring out, their feeble upward flight into the air where they become the food of birds, the hasty death of those that do not at once fly, carried off living to the nests of ants and there devoured: there is an immense waste of life, and the appearance of these winged termites is the signal for so great a gathering of ants and birds that one imagines it to be a well-known thing for which they are on the look-out at this season. Very few have a chance of surviving and even those which shed their wings do not escape, being the more readily carried off by ants.

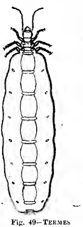
Fig. 49—TERMES OBESUS, QUEEN.

The nest is a most remarkable structure, consisting of numberless chambers and galleries, the walls of a moderately hard substance which is apparently a product derived from the chewed fibre the workers bring in. These nests are often two and three feet in diameter. The situation of the nest varies with the species: the nests of some Indian species are deep in the soil, of others near or at the surface or in banks. Apparently this varies with the nature of the soil, the same species building its nest at different depths in different localities.

The student should consult Petch's paper on the fungi of certain termite nests in Ceylon (Ann. Roy. Bot. Garden, Peradeniya III, p. 185, 1906). Though dealing with species not occurring in our fauna, the account of the fungi is of special interest. The "small white, stalked or almost sessile spheres" observed by him on the spongy masses are probably similar to those observed in the nests of *Termes obesus* in India. The origin and nature of these spheres or their connection with other fungus forms connected with the nests is not clear. The author states that the spongy masses are wholly formed of the excrement of the workers; that this material is probably sterilised by its passage through the alimentary canal, and that not only are special fungi cultivated on it but that other fungi, not desired by the termites, grow which are weeded by the workers; when a nest is abandoned these 'weeds' grow unchecked. He also states that it is probable but not proved that these white spheres form the food of the termites, and that it is not clear if a difference of food causes the differentiation of the forms seen in a termite's nest. The hills are formed wholly of material removed from the nest in excavating and covered with saliva, which the workers take out of the nest and build up into masses; there is no definite object in these chimneys which would probably blow away were the material not covered with saliva and of such a nature as to compact firmly.

Termites are extremely destructive in houses, owing to their fondness for woody matter. On obtaining entry to a house, they will destroy wooden beams and rafters, door frames, window frames and other wooden portions, without such a fact being at all evident at first. Having obtained access to wood at the soil or having taken a tunnel up to it, they work wholly within and remove the woody fibre. No estimate is possible of the amount of damage thus caused in India, and the prevalence of termites varies immensely from place to place. It is on record that in 1814 Government House, Calcutta, was seriously attacked and there seems no reason why any building in which wood was used should not be destroyed in time. Termite communities are so immense and their industry so great that their combined efforts are very effective. In other parts of the world, eatable objects are said to disappear in a night; the only parallel case of recent occurrence in India that can be quoted is a prison in Bengal, in which the bedding of the prisoners was destroyed in the night while the prisoners were sleeping on it. Their efforts are not confined to dead vegetables tissue, but they are particularly destructive to wheat, to sunflower, groundnut and sugarcane. These little insects excrete an acid liquid capable of attacking metal and it has been found that where their galleries cross metal, the metal corrodes.

In reviewing the Termites in *Genera Insectorum*, Desneux regards them as distinct from all families of Neuroptera and as an offshoot of a simpler form of *Blattidæ*. According to this view, the family should follow the *Blattidæ*, but owing to their degree of specialisation he regards them as a separate order under the term *Isoptera*. This is possibly a correct view, and it is undoubtedly misleading, if convenient, to group Termites and the other miscellaneous families in *Neuroptera*; the time has as yet hardly come to separate *Neuroptera* into orders as homogenous and natural as others, and we have preferred to keep them as a family, the order *Neuroptera* being regarded as a convenient group of miscellaneous insects whose position is not quite clear, just as the large series *Polymorpha* includes many very diverse families of *Coleoptera*.

There are nearly 400 species listed by Desneux, of which 15 are recorded from India exclusive of Ceylon.

The following species are known from India:—

Termopsis wroughtoni, Desn., is from Kashmir (Jo. Bo. Nat. Hist. Soc., 1904, p. 445, 1906, p. 293). The only known Himalayan termite (fig. 48).

Termes (Leucotermes) *indicola*, Wasm., from "India."

Termes (Arrhinotermes) *Heimi*, Wasm., from "India."

Termes (Coptotermes) *gestroi*, Wasm., from Burma, and Malaysia.

Termes brunneus, Hagen., from Bengal.

Termes fatalis, Kon., from Ceylon and India.
Termes feæ, Wasm., from Burmah.
Termes Horni, Wasm., from India and Ceylon.
Termes obesus, Ramb., from "India" (figs. 47 & 49).
Termes taprobanes, Wlk., from India and Ceylon.
Termes ferruginosus, Latr., from "India."
Termes (Eutermes) *Assmuthi*, Wasm., from "India."
Termes (Eutermes) *cyclops*, Wasm., from "India."
Termes (Eutermes) *Heimi*, Wasm., from "India."
Termes (Eutermes) *longicornis*, Wasm., from "India and Ceylon."
Termes (Eutermes) *quadriceps*, Wasm., from "India."
Termes (Eutermes) *xenotermitis*, Wasm., from "Burmah."

In a recent paper, Desneux has described a further number of Indian species from Sind (Ann. Soc. Ent. Belg. XLIX, 1905, p. 343). These were found by T. R. Bell who adds notes of the habits. *Hodotermes macrocephalus*, Desn., is described as the common termite of Sind, building underground nests and cutting pieces of grass stems and *Heliotropum* which it stored in the nest. *Termes mycophagus*, Desn., is described as a fungus-growing species, filling chambers underground with masses of soft yellow globules, on which it is supposed fungi grow. *Termes Belli*, Desn., was found nesting in the same spot as the *Hodotermes* above. *Termes Sindensis*, Desn., was also found in Sind.

The termite of the plains of India is *Termes obesus* Ramb., specimens having been obtained from widely scattered places in India. This species nests either deep in the ground, or near the surface, depending probably upon the nature of the soil, but this is not certain. Nests have been found and examined, as also have the small outlying fungus chambers that they make. In some parts of India the nests begin near the surface of the soil and stretch upwards in the form of conical mounds; in other places they are at the surface but not above it; elsewhere they are deep in the soil. This termite never shows above ground unless in a tunnel or gallery: the insects are seen only when they emerge in the winged state; their tunnels were found in Pusa 11 feet below the soil level and were occupied by workers. Where they tunnel so deeply nests are never found; small fungus chambers have been found but no nests;

PLATE VIII.—TERMES OBESUS.

Main and subsidiary fungus chambers, shown from below and from the side. Reduced three times

PLATE VIII

and though the insects appear for instance in every part of the Pusa estate (1,300 acres), no nest can be found; excavations made at the spot whence the winged forms emerged in a great swarm revealed nothing. Usually the queen is found in a cell deep in the nest, with fungus chambers round; her eggs are found in masses in cells in the fungus bodies, small soft white eggs from which the tiny white nymph hatches.

The fungus bodies are found, flattened and concave below, resting on the floors of the cells in the soil but not touching the walls or the roof; they are sponge-like, with ramifying cavities on the walls of which the fungus fruits grow in the shape of small round white knobs. (Plate VIII.)

The forms this termite takes are shown in the figures. We believe this to be the termite responsible for all the damage done to crops, trees and buildings in India, and it is to be hoped that a really thorough investigation may some day be made into its economy and habits.

For a list of insects found in its nests see below under Myrmecophilous Insects (after Paussidæ).

PSOCIDÆ.—*Book Lice.*

Soft insects, of small size, with two pairs of wings, the hind pair smaller; prothorax very small, except in the wingless forms. Tarsi of two or three joints.

The Psocids are a small group of inconspicuous insects, easily recognised by their general appearance and most similar to the smaller forms of Termites. The colouring is generally dull, the wings occasionally banded and the body bright. The smaller forms are all less than one-

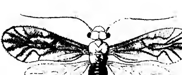

Fig. 70—KOLBEA SOLAX.
(*After Enderlein.*)

fifth of an inch long, the largest never exceeding one-third of an inch. The antennæ are slender, moderately long; there are simple and compound eyes. The mouthparts are peculiar, and are apparently very greatly modified biting mouthparts, small and inconspicuous. The wings and legs are well developed, the former with comparatively few veins. Males and females are similar in general appearance.

The life history is very imperfectly known. Eggs, often covered with excrementitious matter, are laid under webs produced by the parents from silk excreted from the mouth. The young are nymphs similar to the adults in general features and found gregariously with them. One species seems to be common in the plains, its eggs being laid on the leaf under webbing. A far larger and brighter species is found in the moister parts of India on tree trunks; this appears to be *Psocus lemniscatus*, Endl., found also in Java. The species live in the open on bark, under leaves, in damp places under shelter, on leaves; their food consists of animal or vegetable matter in the form of fungi, moulds, bark, etc. Others (*Atropidæ*) live in houses in damp close situations, a damp wall being a favourite place. The commonest species lives thus in houses, in damp paper, in damp corners, and this attacks and destroys dried insects. New insect store-boxes, if damp, breed them in great abundance, the little insects apparently finding food upon the damp paper: when insects specimens are put in, they feed within these and in time destroy them.

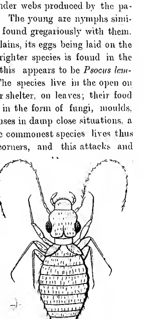
Fig. 51.—ATROPOS SP. (*After Smith.*)

The number of species of Psocids is apparently a large one, but as little attention is paid to them, few are described. Two sub-families are recognised, the winged *Psocinæ* with ocelli, the *Atropinæ* which have rudimentary or no wings and no ocelli.

Dr. Enderleins' paper (Die Copeognathen des Indo-australischen Gebiet) enumerates ten species of the former from the Indian region, chiefly collected by Biro. One European species has been found in the

Himalayas, the remaining species are local. Scarcely anything can be said to be known of the family in India, their minute size and extreme delicacy being unfavourable to collection and preservation.

The recorded species are :—

Psocus longicornis.—F.
Psocus nebulosus.—St.
Psocus taprobanes.—Hag. var. *bengalensis.* Kolbe.
Psocus cinereus.—Enderl.
Copostigma indicum.—Enderl.
Cæcilius himalayanus.—Enderl.
Amphipsocus pilosus.—Macl.
Ectopsocus denudatus.—Enderl.
Myopsocus fraternus.—Hagen.
Perientomum morosum.—Hagen.
Lepium chrysochlorum End.—(Spol. Zeyl. 1906, p. 81).

None are of the smallest economic importance though the insect eating one (*Atropos sp.*) is a great nuisance in the rains when specimens cannot be kept dry. The study of these insects, especially in the moister parts of India, would very greatly increase our knowledge of the group and yield valuable results from the biological, as from the systematic aspect.

GREGARIOUSNESS

If we exclude the purely social insects, in which for the good of the community there is a well marked division of labour accompanied by polymorphism, we find that the great mass of insects are, as far as we know, wholly solitary. Consider the commonest insects there are about us, and watch their ways ; all live for themselves individually and appear to take no notice of each other, except when impelled by the mating instinct. It is perhaps safe to say "apparently" because for all we know there may be modes of inter-communication not revealed by external movements, as there must be certainly in some species of ants. There are, however, a small number of insects constantly gregarious, as apart from "Social" and it is these forms we propose now to mention. The student will think of insects that migrate but these are gregarious only when this migrating instinct overtakes them and at other times are wholly solitary.

Perhaps the commonest instance of truly gregarious insects are the free-living *Psocidæ* which live under a common web in little colonies on the leaves and bark of trees and other plants. Possibly the common link is the shelter that the web provides, possibly there is some faint approximation to the truly social condition. Another instance are the *Embiidæ*. One finds numbers of these delicate insects together using the same silken runs and living in a little colony together. It is doubtful if they ever live in any other way but why they should do so is not clear; the reason that suggests itself is that there are few spots suitable to them and that here they naturally gather and make common runs and shelters. A better and more striking instance is the *Pyrrhocorid* bug *Iphita limbata;* great numbers of this bug cluster together on one spot on a tree trunk, and that they remain there is shown by the heap of exuviæ below the spot. Why they do so is not at all clear; their ally the Red Cotton Bug (*Dysdercus cingulatus*) appears to have the same habit, but this is clearly a case of food or of enhancing their warning colour and they cluster on the seeds or pods to feed or sleep only. The Coreid *Corizus rubicundus*, Westd., lives till mature in clusters which look like vivid red flowers. Some moth caterpillars and a few Pierid caterpillars are gregarious, hatching from eggs laid in clusters and remaining together for a longer or shorter time. Some remain in webbed leaves till they pupate; others for a short time only and in these cases, which are fairly numerous, the web made as a shelter is often the reason. Thus *Caradrina exigua* larvæ remain together for a few days in the webbed leaves as do the larvæ of *Diacrisia obliqua* and many other *Noctuids* and *Arctiids*. An interesting gregarious insect is the common *Machilis* found on rocks and under leaves; it is apparently always gregarious. Young Pentatomids are often gregarious for the first two or three instars, and the persistent way in which some remain together when newly hatched out shows that it is instinctive. Cockroaches are gregarious also and apparently often prefer being in company to being alone. *Gyrinidæ* are distinctly and markedly gregarious and apparently take delight in their combined evolutions on the surface of still water. *Opatrum* among Tenebrionids is gregarious in the sense that the beetles like to crowd together in groups and clusters instead of remaining solitary. *Haltica cyanea*, Web., is another beetle that lives and feeds in company, though such instances are very rare.

PERLIDÆ.—*Stone flies.*

Delicate insects, with the hind wings large and folded beneath the forewings. Legs widely separated, with small coxæ.
Larva aquatic.

These typically Neuropterous insects are distinguished from other allied groups by the above characters, by the long antennæ, and the three-jointed tarsi: as a rule there are two long anal cerci (except in Nemoura). They are inconspicuous insects of which apparently nothing is yet known in India. In general the Perlidæ are, in the immature stages, aquatic; the eggs, laid on the surface of the water, sink to the bottom and hatch to active nymphs; these are flattened, with an elongate body, the head with biting mouthparts; air is obtained by means of tufts of gill filaments; two long many-jointed cerci terminate the abdomen. Those known elsewhere are predaceous, and are found under stones or at the bed of rapidly flowing streams. The full grown nymph is said to crawl out of the water before the emergence of the imago. The family is often classed with the order *Pseudoneuroptera* or is treated as a separate order *Plecoptera*. When more attention is paid to *Neuroptera* in India, they may prove to be abundant in species; they are of no economic importance, direct or indirect. No species appear to be recorded from India.

ODONATA.—*Dragon-flies.*

Two pairs of long narrow wings of equal size; antennæ very small and terminating in a bristle. Head large and mobile. Tarsi three-jointed.

A large group of large insects, easily recognisable from nearly all other insects by their wings, (which are in repose held out horizontally and not resting over the body,) by the peculiar antennæ, the large mobile head and the active habits of the flying insect. The imagines vary in length from an inch upwards with a span across the wings up to four inches. They are, as a rule, brightly coloured, black with blue, yellow, red, metallic green and other bright colours predominating. The colour is possibly warning, probably simply beautiful, though it is difficult to generalize about insects so variously coloured.

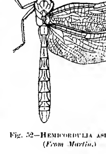

Fig. 52—HEMICORDULIA ASIATICA. (*From Martin.*)

The head is large and very mobile, with immense compound eyes. In some cases the facets on the upper surface are larger than on the lower and this difference may be an adaptation to both long and short sight. The active habits of these insects' necessitates very perfect sight and the compound eyes appear to be very highly developed. The antennae are small, with few segments, and are bristle-shaped. The mouthparts are of the sharp biting type. The thorax is large and the individual segments consolidated into a single mass. The long wings are attached to the sides; the powerful muscles and well-built thorax give the insect very great powers of flight. The legs are placed very far forward on the thorax and this is apparently an adaptation to the predaceous habits of these insects. They catch their prey on the wing, hawking for flying insects; the legs extend forwards below the head in the form of a basket; as the dragon-fly rushes through the air and pounces on an insect the legs grasp the prey and hold it below the head, the dragon-fly remaining in motion throughout. The captive is then devoured. Dragon-flies are found only on the wing or resting on twigs, leaves or grass stalks. The peculiar position of the legs facilitates this method of repose but does not enable the insect to walk. The abdomen is long and thin terminated in claspers or processes. The method of fertilization is somewhat remarkable, the seminal fluid which issues from the tip of the abdomen being transferred to a pouch on the second abdominal segment, which is provided with coupling organs; the male then grasps the female by the neck and she brings the tip of her abdomen to this pouch: in some species this process takes place over the water and eggs are laid in the intervals of coupling. In others the female descends under water, carrying air with her between the wings and body and there deposits her eggs; others deposit the eggs while flying over the water, or while lying motionless on it with extended wings and a few are known to lay them in mud.

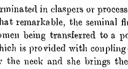

Fig. 53.—AESCHNID NYMPH.

The life history is, so far as known, the same throughout the family. Eggs are laid in water, a mass of eggs in a transparent mucilaginous envelope being deposited. The larvae are active, with three pairs of legs, short antennæ and biting mouthparts of a peculiar type. The lower side of the head is concealed by a development of the lower lip, in the form of a long jointed arm-like structure, which folds down over the mouth and which is armed at the tip with processes bearing strong spines. This jointed arm extends very rapidly to a considerable length, seizes the prey and withdraws it to the mouth, where are the sharp maxillæ and mandibles with which the prey is devoured. Like other aquatic larvæ, these must obtain a supply of air and as they live below the surface, this air must be obtained from the water. This is effected in the *Libellulinae* and *Aeschninae* by taking water into the rectum, the posterior portion of the alimentary canal, which is modified to act as a gill and to extract air from the water: this part of the alimentary canal is penetrated by tracheæ, into which the air is absorbed and which distribute it as in other insects. (Fig. 54) The nymphs can be seen to take in and eject water from the hind end, the violent ejection of water also serving to propel the nymph forward and assist it to obtain its prey. In the *Agrioninae*, the nymph is provided with three flat lamellar appendages at the apex of the abdomen, which function as gills. (Fig. 55).

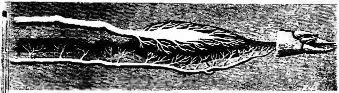
Fig. 54.—ALIMENTARY CANAL AND TRACHEÆ OF AESCHNID NYMPH.

Like the adult, the nymph is predaceous, the teeming fauna of fresh water supplying it with an ample supply of food. When fullgrown, the nymphs climb up out of the water, the skin breaks along the dorsum, and the perfect insect emerges: the wings are gradually developed out-

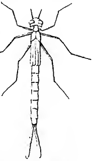
Fig. 55.—AGRIONID LARVA.

side of the body in the nymphs, as in the *Orthoptera*, and the metamorphosis is thus an incomplete one. It is more complete than in the *Orthoptera*, as there is one sudden change from nymph to adult, when the insect from being a repulsive crawling creature becomes suddenly winged and aerial ; but it is incomplete in the sense that there is no resting pupal stage as in the *Hymenoptera*.

It is impossible to discuss the extremely interesting variations, which are found in the nymphs of various species, in the manner of life and respiration ; the aquatic insect fauna of this continent appears to be a sealed book and nothing is known in detail. Nymphs have been found living in dried up pools, apparently not injured by the absence of water and obtaining air directly. It is doubtful to what extent this occurs, and whether there are any species that live so habitually.

Odonata are found abundantly throughout the plains and in forest areas. The number of species is very large and an account of the family as it occurs in India is much wanted. The imagines have quite peculiar habits, and are very characteristic. They play a large part in the destruction of smaller winged insects, especially flies, their appetite being apparently insatiable. It is often observed that each individual has its own beat and it is known that when they are abundant, each confines his operations to a particular spot, returning to rest on the same twig.

The length of the life is not known but it is apparently long both in the nymph and the adult condition. A few dragon-flies are among the

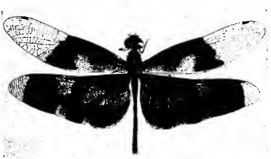

Fig 56—RHYOTHEMIS VARIEGATA, FEMALE.

gregarious insects and it is not uncommon to find large numbers flying together over pools in the jungle. The bright winged species of the moister areas of Bengal are frequently seen flying in groups, and one brilliant yellow species (*Rhyothemis variegata* F.) is commonly seen in Calcutta. Migration has been known to occur elsewhere, though not recorded in India.

The *Odonata* are by some authors treated as a single family, with two divisions and seven sub-families as is done here, or as a sub-order with three families, or with seven families.

ANISOPTERIDES	1. LIBELLULIDÆ ...	Corduliinæ. Libellulinæ.
	2. AESCHNIDÆ ..	Gomphinæ. Cordulegasterinæ. Aeschninæ.
ZYGOPTERIDES ...	3. CALOPTERYGIDÆ ...	Calopteryginæ. Agrioninæ.

Anisopterides.—Hindwings broader at the base than the forewings. Wings held horizontally outwards from the body when at rest. (Figs. 57, 59.)

Zygopterides.—Wings equal or hindwing small; wings held closed together vertically above the body when at rest. (Fig. 58.)

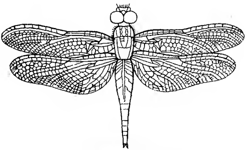

Fig. 57.—ACISOMA PANORPOIDES.
(*From Rambur.*)

Over 130 species are listed or described from India. Rambur monographs the older species (Neuroptera 1842). De Selys' many papers contain descriptions of a large number of species; Kirby has described species from Murree and Campbellpur (Proc. Zool. Soc. 1886, p. 325), the European *Sympetrum fonscolombei* de Sel. being found there; he has added descriptions of species from Ceylon and Upper Burma (Ann. Nat. Hist. VI, 14, and VII, 15); a large collection made by G. C. Nurse at Deesa and Quetta is described by Martin (Trans. Ent. Soc., London, 1907, p. 303). The species up to 1890 are catalogued in Kirby's Catalogue of Odonata and there have been stray descriptions by other authors since then.

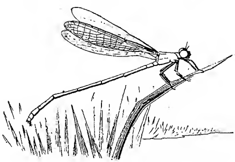

Fig. 58.—AGRIONID AT REST.

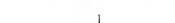

Fig. 59.—AESCHNID AT REST.

AQUATIC INSECTS.

A considerable portion of the insect world live in or on the surface of still or running water, and are more or less specially adapted to the peculiarities of this mode of life. These insects are derived from terrestrial insects and there is no hard and sharp line between terrestrial and aquatic insects. We have, for instance, the predaceous Reduviid bugs on the earth which live also on mud and in the neighbourhood of water. It is but a small transition to the *Hydrometridæ*, bugs which run on the surface of the water and which require very little modification, chiefly in the structure and motions of the legs. The aquatic carnivorous beetles are very closely allied to the land carnivorous beetles, the modifications mainly consisting of those necessary to enable the beetle to swim, to obtain air below water and to catch different prey. The *Hydrophilidæ* include both land and aquatic forms in one family, and were our knowledge of past and present day insects greater, we might be able to trace the steps by which a land insect gave rise to aquatic forms. The aquatic Diptera are excellent examples, some living in mud, some in shallow water, some in deep water. We may suppose these to have more recently acquired the aquatic habit than such a homogeneous group as *Odonata* or *Ephemeridæ* which are now wholly aquatic and were probably derived from primitive land ancestors.

Among aquatic insects, one of the most interesting features is the manner in which the air supply is obtained. Assuming that all aquatic insects are descended from terrestrial ancestors, and not from a single form which became aquatic, we would expect different groups to solve this problem in different ways and to find a great variety of devices to secure an air supply. In general mature insects obtain their air direct from the atmosphere, rising to the surface to do so, and there are among them fewer modifications in the respiratory system, possibly owing to the greater rigidity of the outer skeleton and the far smaller degree of plasticity of the adult constitution as compared with the larval. We may, therefore, consider the larval and pupal forms of aquatic insects, extremely briefly, solely from this point. Insects are commonly provided with one or two thoracic spiracles, and a series of five to eight on the abdominal segments. This, the so-called holopneustic (2 thoracic) or perineustic (1 thoracic) system obtains in adults but not, so far as we are aware, in larvæ. The first modification we find is the closure of all spiracles but the two terminal pairs, one near the head, one nearest to the tail (Amphipneustic). The closure of these spiracles is actual, but the spiracle remains, a tracheal vessel runs to it which contains no air as a rule. The larva of *Pericoma* (*Psychodidæ*) and allied larvæ are examples, and air is obtained by bringing either of the pairs of spiracles to the surface. A far commoner modification is the metapneustic one, where only the terminal abdominal spiracle persists in a functional state, being usually very large. A large number of insects exhibit this character in the larval state including *Amphizoa*, *Dysticidæ*, most *Hydrophili-*

dæ, *Helodes* (*Dascillidæ*), *Culex*, *Dixa* and *Anopheles* (*Culicidæ*), *Tipulidæ*, *Stratiomys*, *Tabanidæ*, *Syrphidæ*, and *Sciomyzidæ*; in these it obtains in the larva, and not always in the pupa, though in *Stratiomys* and *Hæmonia*, for instance, the pupa also exhibits it. In a few, we get the complementary state, in which the anterior spiracle alone is functional, as in the pupæ only of *Culicidæ*, *Chironomidæ* and *Dixidæ*.

In the above there have been in all cases at least one spiracle functional and the normal tracheal system. In those that follow, there are no functional spiracles, unless one of the above systems is combined with it; most larvæ exhibit one of the above modifications, with one or several of the following, though the latter may occur alone or in combination with each other. *Tracheal gills* alone, with no other definite system, occur in a number of larvæ; in these the skin is produced into thin-walled tubular structures in which the body-fluid circulates, in which there are tracheæ, and which function as gills since they absorb (or are supposed to absorb) oxygen but are tracheal and not true gills since the air is passed into the trachea and not, apparently, into the "blood" system. Such gills take many forms but are commonly tubular or paddle-like, in tufts, in spongy masses; they occur in larvæ which do not come to the surface but live wholly in the water at some depth usually, as in the *Perlidæ*, *Ephemeridæ*, *Sialidæ*, *Sisyra* (*Hemerobiidæ*), *Haliplidæ*, and *Calopterygides* (*Odonata*), and in the subfamilies *Phryganeides*, *Sericostomatides* and *Leptocerides* of the *Phryganeidæ*. These gills may be on the eight basal abdominal segments (*Haliplidæ*), on the seven basal abdominal segments (*Sialidæ*), on the apex of the abdomen (*Chironomidæ*), *Corethra* (*Culicidæ*), *Simulium*, and the Calopterygine division of *Odonata*, on the base of the abdomen (*Perlidæ*, some *Ephemeridæ*) or on the whole abdomen (*Gyrinidæ*, *Phryganeidæ*).

Accessory tracheal gills also occur, in combination with a spiracular or other combination, as in *Dixa*, *Culex*, *Mochlonyx* and *Helodes*. Such accessory gills are extremely common and cannot always be easily distinguished. Rectal respiration is another modification of tracheal respiration, in which water is taken into and discharged from the rectum, which is set extremely densely with tracheæ and functions as a "water-lung" or gill. *Odonata* (exc. *Calopterygidæ*) are the best examples, the very young Chloeon (*Ephemeridæ*) is another and both *Culex* and *Ceratopogon* also exhibit it.

There are finally some modifications in which tracheæ play no direct part: the skin possibly functions as a "gill" in many of the young larval forms, in which there is no other system developed; this is a matter of conjecture largely, but there is no other available explanation of the respiration of many young aquatic forms. Some *Phryganeidæ* and *Perlidæ* never exhibit any other respiration throughout larval life, and it is presumed the air is obtained through the skin.

"Blood-gills" are gills as opposed to tracheal gills, since only the body-fluid circulates in them and no tracheæ enter them, or if they do, do not contain or carry air; the gills of *Pelobius*, *Hydrocyphon* and some *Chironomus*, the rectal pouches of *Macronema*, the gills of some young *Phryganeids* and *Ephemerids* are of this class, though in the last there is little real distinction from tracheal gills.

There are a small number of insects in which air enters the body cavity and this is so extraordinary a phenomenon that though we know of it in only two insects, we mention it here. It deserves fuller investigation. Another peculiar method is found in larvæ which take air into the alimentary canal, either swallowing it as does one aquatic larva, or as Odonata do, at the hind end; this is often seen in the latter in captivity, and is simply a modification of the rectal gill.

Finally, there are the insects which contain a red pigment allied to or identical with Hæmoglobin, the constituent of man's blood that carries oxygen in weak combination from lung to tissue and Carbon Dioxide to the lung. *Chironomus* is the familiar example, found in every Indian tank, and we use this generic name in a very broad sense to include many forms allied to Chironomus but not identified.

For the benefit of the student we attach the table of modifications mentioned above.

- I. Tracheal:
  - 1. Stigmata:
    - *a* *Holopneustic.*
    - *b* *Peripneustic.*
    - *c* *Amphipneustic.*
    - *d* *Metapneustic.*
    - *e* *Propneustic.*
  - 2. No Stigmata:
    - *f* *Tracheal gills, main.*
    - *g* *Tracheal gills, accessory.*
    - *h* *Rectal gills.*
- II. Without tracheæ:
  - *i* Skin, wholly or in part.
  - *j* Blood-gills.
  - *k* Entrance of air to body.
  - *l* Entrance of air to gut.
  - *m* Pigment.

Summary of aquatic families.—The following review does not pretend to mention every aquatic form or group, but contains the majority, and probably every important family.

Aptera include aquatic forms living on the surface of water. *Podurinæ* are known to have this habit and, were we to include the marine forms, the well-known *Anurida* could be cited. Aquatic *Orthoptera*, while rare, are not unknown. A description of an aquatic Gryllid (*Hydropedeticus vitiensis* Mial. and Gil.) will be found in Trans. Ent. Soc., Lond., 1902, p. 281. *Tridactylus* is found on the surface of water but usually lives on mud. (See p. 99.) Annandale has found an aquatic *Blatta* in Malaya and an aquatic *Epilampra* in India (Journ. Asiatic Soc., Bengal, 1906, p. 105). In India, one genus at least of Tetriginæ (*Scelimena*) is aquatic and an Acridiid allied to *Hieroglyphus* has the habit of diving below the surface.

Amongst *Neuroptera*, there are several important groups. The *Perlidæ* (Stone Flies) have aquatic nymphs, which have ten pairs of closed stigmata, and functional gills as a rule. A few are stated to have no gills but to have special tracheal developments at the skin. Others have gills on the first thoracic segment (*Nemoura*, *Pteronarcys*) on the sides of the thorax (*Perla*, *Pteronarcys*, *Nemoura*), on the apex of the abdomen (*Perla*, *Pteronarcys*) or on the head (*Dictyopteryx signata*). The *Odonata* are wholly aquatic with two modifications; the *Calypterygidæ* have leaf-like processes functioning as tracheal gills, the *Aeschnidæ* and *Libellulidæ*, rectal gills with anal valves to admit water, the gills in the former being *papilliform*, in the latter *lamelliform*. The *Ephemeridæ* are also aquatic with gills in the older stages. Lubbock has remarked that the skin of *Chloeon* functions till the third instar, when gills appear, but the tracheæ are functional only in the fourth instar (there are 20 instars). Gills take several forms, and may be large and exposed, flat lateral plates, tubular under a gill cover, or concealed. The long caudal setæ have a circulation and are probably also respiratory. Of the *Sialidæ*, the *Sialinæ* live in mud, the first seven abdominal segments having filaments functioning as gills. Of the *Hemerobiidæ*, the *Hemerobiinæ* contain two aquatic forms, *Osmylus* and *Sisyra*, the latter with abdominal tracheal processes. The *Trichoptera* are wholly aquatic in the larval stage, having no gills (some *Hydropsychides*, *Rhyacophilides*, *Hydroptilides*), or having gills in the form of tufts or slender processes, which may be placed all round the body.

The *Hymenoptera* include a few remarkable parasitic forms which deposit their ova in the larvæ of Trichoptera or other aquatic insects. *Prestwichia* in Europe is parasitic in the eggs of six species of aquatic insects.

The Coleoptera include eleven families aquatic wholly or in part at least in their larval stages. *Amphizoidæ* are metapneustic as larvæ. The *Pelobiidæ* are represented by *Pelobius* whose larva is said to have spiracles and blood gills. The larval *Haliplidæ* have long filaments on the abdominal segments. *Dytiscidæ* are wholly aquatic, the larva metapneustic, the imago carrying air under the wings. *Gyrinidæ* live on the surface of the water as adults, but the larvæ are provided with ten pairs of abdominal tracheal processes. The *Hydrophilidæ* are only in part aquatic; their larvæ are either metapneustic or have tracheal processes (*Berosus*). *Platypsyllidæ* are scarcely aquatic save in that their host the beaver is so. *Heteroceridæ* are semi-aquatic in mud or wet sand in all stages. *Parnidæ*, so far as known, are peripneustic or have filamentous branchiæ ; the *Elmides* have three pairs.

Dascillidæ are aquatic and while some have functional spiracles, others are said to have exsertile respiratory pouches (*Hydrocyphon*) ; a few forms of the *Donaciinæ* among Chrysomelidæ have aquatic larvæ, the larva being found in the roots of aquatic plants. (*Donacia*, *Hæmonia*.) We have omitted to mention the abnormal aquatic Carabid found extremely rarely in England and Annandale has recently described an aquatic weevil from Calcutta (Journ. Asiatic Soc., Bengal, 1906, p. 197) as well as an aquatic glow-worm larva (loc. cit. 1906, p. 107).

Few Lepidoptera are aquatic but some are very notably so in this country. A single Pyralid genus (*Acentropus*) has an aquatic larva (not known in India) : the *Hydrocampinæ* include at least several aquatic forms including *Nymphula depunctalis* Guen and *N. fluctuosalis* in which the larva is set with short respiratory processes. Both these are common in India, while *Hydrocampa*, *Paraponyx* and *Cataclysta* are known elsewhere.

A single abnormal Eupterotid is aquatic, the larva of *Palustra Burmesteri* being holopneustic but having a covering of long hairs in which air is retained ; it comes to the surface to renew the supply. Of *Diptera* we are still largely ignorant but the *Culicidæ* have aquatic larvæ, variously modified, as do the *Chironomidæ*. *Corethra* is in the larval state dependent on tracheal gills ; *Culex*, *Anopheles* and others are metapneustic, but have tracheal gill processes as well ; in all, the pupæ are *propneustic*, the anterior spiracles lying within large trumpets which are brought to the surface of the water. *Chironomidæ* include the forms with *hæmoglobin* (*Chironomus*) as well as those with tracheal gills : the pupæ are propneustic or have tufts of gills. The aquatic *Ceratopogon* larvæ appear to have no gills and to breathe through the skin. *Psychodidæ* have aquatic or semi-aquatic larvæ, living in algæ and weeds. with four ciliated processes at the hind end forming a basin round the spiracles, as well as a functional pair of anterior spiracles. *Dixidæ* have metapneustic larvæ with tracheal gills, the pupa with propneustic trumpets. Aquatic *Tipulid* larvæ are well known and are metapneustic. some with a long telescopic tail process (*Bittacomorpha*, *Ptychoptera*). One at least has long tracheal filaments (*Phalacrocera replicata*). The larvæ of *Blepharoceridæ* are known to live in torrents and near waterfalls, clinging firmly to rocks. *Simuliid* larvæ are found in swiftly running water and have five retractile gills ; the pupa has a tuft of filaments. *Stratiomyidæ* have some aquatic larval forms, the larva metapneustic with an expansible ring of hairs that hold an air bubble.

Tabanidæ have metapneustic aquatic larvæ, as do the *Syrphidæ* in some cases, the latter having in some forms (*Eristalis*, *Helophilus*), the long telescopic tail process with the spiracles at the apex; the pupa is propneustic with the spiracle on the tubular filaments. It is known that some *Acalyptrate muscidæ* have aquatic larvæ, *Dasycerides*, *Ephydrides* and *Sciomyzides* being thus found.

The above includes the majority of the forms with aquatic nymphs or larvae, but we may remember that in almost any tank or stream there are abundant new forms as yet unreared, and that aquatic insects are by no means well known. We are familiar with many fresh-water larvæ which do not come into any of the above groups, and the Indian aquatic fauna is almost unknown.

The following Hemiptera are aquatic in all stages, but all are holopneustic or peripneustic. The *Hebridæ* are scarcely truly aquatic, living in damp situations, the body beneath densely pubescent. *Hydrometridæ* live on the surface of the water, being also pubescent below. The division *Cryptocerata* are aquatic, living below the surface but being holopneustic or peripneustic in all stages; *Pelogonidæ* (*Galgulidæ*) are alone found on wet mud and near water. *Nepidæ* live in shallow water and obtain air by means of two processes which unite to form a slender tube; the nymph obtains air by means of two ventral pubescent grooves leading to the apex of a short process. *Naucoridæ* carry air down with them in a bubble attached to the hind end and come to the surface to renew it; *Belostomidæ* are also aquatic and obtain air from the surface. *Notonectidæ* and *Corixidæ* carry air on the lower side of the body and come to the surface to renew it.

So far as we are aware, there remains only one aquatic Hemipterous insect, an Aphid (*Rhopalosiphum nymphea* Fabr.) found in India below the surface of fresh water on an aquatic plant.

In the above aquatic insects, we have indicated the fact that the actual habitat in the water may be very different, and it will be useful to briefly note the habitat conditions that we find. There are many forms which never or only exceptionally leave the surface, such as the Gyrinid beetles, the larvæ of *Dixa* and *Anopheles* and the various *Hydrometridæ;* they are aquatic only in the sense that they live on water and are adapted thereto.

Others live near the surface and always within reach for air-getting purposes. Of these some live in algæ or weed masses as *Palustra* larvæ, the pupæ of aquatic *Tipulids*, the larva of *Stratiomys* and the larva and pupa of *Psychodidæ;* others are in mud at the margin, as *Ptychoptera* and *Bittacomorpha*, the Tabanid larvæ, the larva and pupa of the *Eristalis* and *Helophilus* sections of *Syrphidæ*.

A number are dependent on the surface, but go deep in search of food or shelter; such are the predaceous beetles (*Dytiscidæ* and the like), the Hydrophilus beetles, the aquatic *Cryptocerata*, as well as the *Culicidæ* and *Dixidæ*.

When we leave the surface, we find a number that live in the middle depths; the peculiar mining larva of *Dorycera*, the red *Chironomid* larvæ found in the soft stems of aquatic plants, the larvæ of *Ephemeridæ* in the holes in the bank, the many larvæ in masses of algæ or weeds (*Ceratopogon*, *Acentropus*, *Hydrocampa*, *Cataclysta*, *Paraponyx*, *Nymphula* and *Simulium*), the few larvæ that live actually free in the water in the middle depths (*Corethra* and *Chironomid* larvæ), are examples of insects neither dependent upon the surface for air nor finding food at the bottom, and which are commonly obtained with a net in the middle depths.

There are also the insects in the depths or on the bottom; the *Perlid* larvæ are under stones; the mud-loving *Sialidæ*, the larvæ of caddis-flies and dragon-flies are found on mud; some are found only at the bottom of shallow running water, including caddis larvæ, the nymphs of *Odonata*, *Perlidæ* and *Ephemeridæ*, as well as such aquatic *Hemerobiides* as are not found in sponges.

Finally, there is the remainder, which are at all depths except near the surface, which range over the bottom and middle; these include the more active *Odonata* and *Trichoptera*, the larvæ of *Haliplidæ*, *Gyrinidæ* and *Parnidæ*, as well some of the *Hydrophilidæ* (Berosus). A far larger part of the aquatic fauna would naturally come within this last division were one to go minutely into it, which is impossible in this place.

Sufficient has been said to show that aquatic insects live in a world of their own, one as complex in its internal relations as that of the land; we find herbivorous insects, preyed on by carnivorous ones, occasionally attacked by parasitic ones; it is a teeming world of life of all kinds, of immense interest from every point of view and especially so from the aspect of the immensely ingenious contrivances by which insects obtain their air supply. But it is a subject which has been scarcely touched in this country, though there are unrivalled opportunities at almost all times; we anticipate that the investigation of how these insects pass through the time when tanks dry up will yield some extremely interesting results, and we may hope that, though there is no economic side to it, this fascinating branch of entomology will some day be attacked.

EPHEMERIDÆ.—*May-Flies.*

Slender insects with large forewings and small hindwings. The antennæ are short. There are two or three long processes on the abdomen. Tarsi four or five jointed. Larva aquatic.

This is the last family in which the wings are formed in the active nymph outside the body as in *Orthoptera*. The wings are, in repose, held together above the body in an upright position and, with the long anal processes, are very distinctive. Some are small very delicate insects, not longer than 5 mm. with a span of nearly 10 mm.; otheis are larger, but none are very large. Eyes are larger in the males than in the females, the upper portion with larger facets than the lower and sometimes divided. In some cases the upper half is much larger and raised on a large projection above the head. The antennæ are short, the mouthparts feebly developed or absent. The mesothorax is well developed, the abdomen sessile, ten-jointed and glabrous. There is no ovipositor; the male has longer forelegs (often very long) than the female, and distinct jointed claspers. The venation is complex. The colours are grey or pearly, the wings transparent, faintly tinged, or with dark markings.

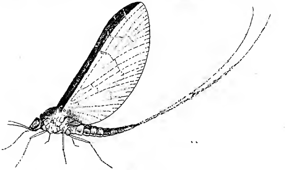

Fig. 60.—EPHEMERID. (F. M. H.)

The life-history is similar to that of other aquatic insects. Eggs are laid in water, either loosely or in compact masses; Eaton records seeing *Baetis* descend under water to lay her eggs under a stone and this is apparently habitual in some species. The nymphs are slender insects, usually with long abdominal processes, with long antennæ and well developed biting mouthparts. The food is said to be mud, or minute aquatic vegetation, but some are certainly predaceous. They live in various situations and beyond the fact that they are to be found in fresh water in India, not much is known. All have gills on some part of the body for the purpose of extracting air from the water; these are situated on the abdomen and consist of thin walled processes in which the body fluid circulates and in which tracheæ are found. In fact, the gills supply the tracheæ with air and are not gills in the same sense as in fishes. The form of these nymphs in general is very varied, as are their habits and there will probably be found a similar variety in Indian species. The reader will find general information in Miall's Aquatic Insects, in Sharps' Insects and in Eaton's Monograph. A curious feature of the life-history is the very sudden transformation; the full-grown nymph comes to the surface, the skin breaks along the back, the flying insect emerges; but its metamorphosis is then not really complete and the insect (now called a sub-imago) flies to a spot on which to settle, then sheds another delicate skin. This phenomenon is known only in this family. One species common in the plains flies some hundreds of yards before doing this and comes to light, settles on the wall and then emerges fully developed, leaving the delicate skin behind.

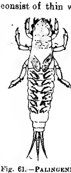

Fig. 61.—PALINGENIA LARVA, CEYLON. (*After Eaton.*)

The nymphal life is probably as long relatively as the imaginal life is short. The May-flies are types of the brevity of life, but in reality these insects have previously enjoyed a very long life (for an insect) in their aquatic form. Lubbock found that the nymph of a European species underwent twenty moults. The perfect insects apparently emerge to a brief career of enjoyment. May-fly dances are a common feature of a still warm evening, the delicate insects (males) performing intricate evolutions in companies on the wing. A dance in three dimensions may have advantages over the dance on the two dimension dance-floor and we can compare it only to a dance of flying machines. These dances take place often at a considerable distance from water, a number of the insects gathering together for the purpose and forming a very striking sight. Coupling and egg-laying closes the brief life. As the mouthparts are absent and no food is taken after emergence, an active life must soon close, and it is probably correct to say that May-flies do not live for more than one or a few days. The immense swarms of May-flies that emerge simultaneously in some countries do not seem common among

Indian species, and these insects appear during long periods in the hot weather and rains, but not in large numbersat any one time. As these insects in their feeding life live a purely aquatic life, there are none of economic importance and the group, as a whole, has attracted little attention in this country. The number of species known is small, as they are not attractive to collectors.

In his monograph, Eaton describes the known Indian and Ceylonese species (Trans. Linn. Soc., Zool. III). Eaton also mentions ten species from India (J. A. S. B., LX, p. 406) and discusses them, mentioning also that McLachlan possessed nine species from Tenasserim. The total recorded by him is twenty-two species, but our common plains species are apparently undescribed, the recorded species being from elevations above 4,000 feet in Ceylon or the Himalayas in most cases.

Collecting.—Imagines and sub-imagines are best preserved in spirit as their integuments are weak, but when plentiful, a series may also be pinned.

THE RELATIVE DURATION OF LIFE.

The actual duration of life measured in human units, is a matter of very considerable variation among the diverse forms of insect-life. From the extremely short-lived Drosophilid fly to the long-lived Cicada, there is an infinite variety; this is a matter of small importance since the passage of time has a relative value and the insect which lives for but a few days may pass through as many experiences as a human being in as many years. The point is, perhaps, interesting as popular ideas are often extremely erroneous and forget to take into account the fact that a winged insect whose life is but a day may have passed weeks or months in an immature form.

Factors which govern the duration of life are many and varied; fall of temperature suspends activity to a greater or lesser extent, and, while prolonging the actual length of life, does not add to the active living period. Abundant food by hastening maturity and the development of the reproductive system may materially shorten the life of an insect: unnutritious food or the lack of food may immensely prolong life either by preventing the immature insect from deriving sufficient nutriment from its food or by checking the development of the reproductive organs, so that life is maintained for long periods until the eggs are formed and egg-laying becomes possible. The absence of the larval food-plant is another factor which prolongs the life of the adult, since the mother insect will remain alive until eggs are laid on the food-plant unless this period is so long as to exhaust her vitality.

What terminates an insect's life? If we consider the insects which escape their foes, which do not die of injury, of parasites or of disease, but which die a natural death, what brings about the cessation of life? Speaking very broadly, the full exercise of the natural functions of reproduction brings a speedy end, perhaps from exhaustion, perhaps from a lack of vitality now that there is no further object in life. The locust dies, if a male after coupling, if a female after the deposition of all the eggs, though food may be abundant and the conditions apparently suitable for further life. The moth dies after mating or laying eggs, and the life of many moths is limited to one or two nights if reproduction is effected, though it may be much extended if mating and egg-laying be not possible; and this is true even of moths that cannot feed and in which the alimentary system is wholly undeveloped.

In estimating the natural life of an insect, we have to consider the time required to build up the tissues of the larval or nymphal as well as those of the subsequent imaginal form, the time required to reproduce, as well as the conditions of food-supply and temperature under which life is carried on. For many, the conditions of food-supply and temperature are such that a yearly period covers the whole life, there being one brood yearly. For others, one active season is not sufficient for the larval form to lay up sufficient nourishment to provide for the tissues of the imago; or this may be possible during the limits of a season or two seasons, but the processes of transformation cannot be completed in time to allow of the imago to emerge, mate and lay eggs at a favourable season and before the rigours of winter or drought prevent the imago from providing for the young. Thus we get a two-year or a three-year period, the whole life from egg to egg occupying multiples of one year. In rare cases (so far as known) this period may be peculiarly long and the Cicadas are notorious in this respect; the 17 years of *Tibicen septindecim*, and the 13 years of *Cicada tredecim*, both American insects, are notorious instances. Turning to shorter-lived insects, we find for instance the two-brooded butterflies, in which there is one quick brood in the rains, and one longer brood which persists in some form through the cold and dry weather till food is again available on the coming of the rains or perhaps at the opening of the buds in spring. From these, a large class probably, we come to those which have several broods in the limits of the hot weather and rains and which have one longer brood, with a long inactive period in the colder weather. The active periods in these cases are the same, but one brood must pass through the long inactive period.

We come finally to normally very short-lived insects such as many Diptera, in which the egg, the larval, the pupal and the imaginal life are contained within perhaps 14 days, the actually known shortest being about 7 days. For these insects life may be long, but given the optimum temperature, plentiful food, abundant flies hatching out together, and a suitable food-supply for the young, on which the parent may lay eggs, the period is reduced to the least possible, the egg hatches quickly, the larva quickly lays up food, the transformation is quickly accomplished and the flies quickly find mates. It will serve no useful purpose to attempt to summarise more closely than above, but we may indicate briefly the characteristics in this respect of some of the larger groups, with regard to Indian insects primarily, but where our knowledge fails, to the group as a whole. The known Cicadas are the longest, the known Drosophilides, Culicides and some other Diptera the shortest. Blattids appear to be long, four years or less for some species. *Mantidæ* are probably at most two-brooded in the year, many probably one-brooded. The same is probably true of Phasmids; Acridiids require one year, or have two, three or four broods yearly, probably more only in rare cases (such as *Chrotogonus* and *Atractomorpha*). *Locustidæ* are probably one-brooded in most cases and nothing is known of Gryllids, though there is reason to believe that some are many brooded, most one-brooded.

Most of the known aquatic Neuroptera seem to be two or more brooded, imagos appearing several times in the year and the period in *Ephemeridæ*, for instance, is probably normally short enough to give several broods yearly. The larger *Neuroptera Planipennia* are apparently one-brooded, but the predaceous *Hemerobiides* and *Chrysopides* are many brooded. Predaceous land Neuroptera, like many other predaceous forms, seem to have the power of enduring long fasts and the life-history may be much prolonged accordingly.

Tenthredinidæ are many brooded so far as known, and the period for many parasitic Hymenoptera is very short, shorter than that of their hosts in many instances. Aculeata have short lives, several broods usually being produced in a year, and here we have an instance where the completion of sexual functions does not bring death, since workers have none; their life is however not long, the worker being exhausted within a comparatively short time (in the bee six weeks). A large number of *Coleoptera* require a year for complete life and many emerge as imagines only at one season yearly. This does not apply to *Coccinellidæ*, to some *Buprestidæ*, to household and grain beetles, to some *Chrysomelidæ* and *Curculionidæ* (e.g., *Apoderus*, *Hypera*, *Cionus*). On the other hand, many *Carabidæ*, *Cicindelidæ*, *Scarabæidæ*, the larger *Elateridæ* and *Buprestidæ*, *Cantharidæ* and many *Curculionidæ* have a period of at least of one year; while some *Cerambycidæ*, the large forms of *Lucanidæ* and *Scarabæidæ*, probably require more than one year. In *Lepidoptera* we have some which require but a month, and complete six to eight broods yearly, and those which require a year and emerge once only; but the majority have at least two and many, more than two broods. Our ignorance of *Diptera* is profound, but the order certainly includes some of the shortest lived and probably few really long-lived ones. Perhaps Diptera are summed up best by saying that the majority have short lives if food is plentiful but long ones if it is not, and some species normally have long lives (special parasites, such as *Bombyliids*, *Conopids*).

Few Hemiptera have been reared, and we must fall back on what is known of the periods at which the imagines appear. A few *Pentatomidæ* appear to breed often in a year, whilst some are probably two-brooded, a rains and a dry weather brood; some are probably only one-brooded. The same is probably true of *Coreidæ*. *Lygæidæ* and *Pyrrhocoridæ* appear to include more species which breed several times, as do the *Tingidæ*. *Reduviidae* are probably few brooded, as well as *Capsidæ*, but the latter in some known cases breed quickly.

Cicadidæ possibly all require at least one year, while some are very long-lived, and it is quite possible that our Indian species follow the examples of the known long-lived ones. The smaller Homoptera (*Fulgoridæ*, *Membracidæ*, *Cercopidæ*) are probably two or more brooded, but it is doubtful if any have more than four broods yearly owing to the lack of food. *Aphidæ* are comparatively short lived with plenty of food, but as they are viviparous, an aphis may often live to be surrounded by several generations of children, grandchildren, and so on. Given good circumstances the number of broods in a year may be very large, without the life of the insect itself being naturally very short. *Aleurodidæ* and *Coccidæ* are, for so small insects, apparently long-lived, but they appear on the whole to have several broods a year, while some are only one-brooded.

The student will recognise that so brief a summary is of little value save as a suggestion and as an indication of the scope of the relative life. Further details are given under each family.

There are two methods of finding the length of life of insects, one the actual rearing or observation of the living insect in all stages, the other the knowledge of the seasons at which the imago appears and the length of its life; an insect that appears but once yearly may have a yearly period or one in multiples of years, but cannot have a less period than a year. The duration of life in the long-lived American Cicadas was deduced from the years in which the imagines appeared abundantly, a matter of such importance that records extending back many years gave the necessary information.

SIALIDÆ.

Wings of nearly equal size, hind wings not folded (cf. Perlidæ), at an angle over the abdomen when in repose. Antennæ long. The wings are not closely reticulate (cf. Hemerobiidæ). Tarsi five-jointed. Larva aquatic, with a quiescent pupa.

A small group of moderate-sized insects, distinguished by the wings and five-jointed tarsi from the *Perlidæ* which most resemble them.

There are two sub-families, *Sialinæ* with quadrangular prothorax and *Raphidiinæ* with elongate prothorax.

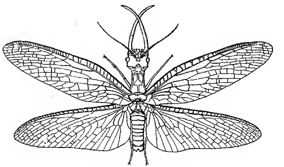

Fig. 62.—CORYDALIS ASIATICA.
(*From Wood-Mason.*)

Of the former the larvæ of the known species are aquatic, hatching from eggs laid near the water; the larva has biting mouthparts, a conspicuous head, long legs and the abdomen has a jointed gill-process on the side of each segment. They are probably predaceous and live for choice in mud. Only a small number of species are known. *Corydalis*, the very large Sialid, common in America, is recorded by Wood-Mason in India, *Corydalis asiatica*, W. M. (fig. 62), being found in the Naga Hills. (Proc. Zool. Soc., 1884, p. 110.) *Chauliodes subfasciatus* Westw. is figured in Cabinet of Oriental Entomology; *C. maculipennis* Gr. (Griffiths' Animal Kingdom, pl. 72, fig. 1) is also known from India. Three other species of *Chauliodes* are described by MacLachlan, Weele and Walker, and 8 species of *Neuromus* by MacLachlan, Weele, Walker and Rambur, all from the Himalayas or Assam.

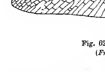

Fig. 63.—CHAULIODES MACULIPENNIS.
(*After Cuvier.*)

Of the *Raphidiinæ*, none are known in India.

PANORPIDÆ.—*Scorpion-Flies.*

Head prolonged into a distinct beak with biting mouthports. Two pairs of wings of equal size held ot on angle (or wingless.) The male with the apex of the abdomen turned up, the apical joint swollen, os in a scorpion. Torsi five-jointed.

These singular insects are at once recognizable from the peculiar head. They are of moderate size, found flying in wooded places, and easily distinguishable. The antennæ are long; the wings moderately large and held out from the body. The abdomen is long, in the male turned up as in a scorpion's tail, in the female straight and tapering.

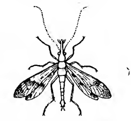

Fig. 64.—PANORPA FURCATA. (*After Hardwicke.*)

The common Indian species are apparently similar to the European form, whose life history is known; the eggs are laid in a mass in the ground; from them hatch larvæ in the form of caterpillars, which feed upon decaying vegetable matter usually underground; the larvæ have imperfect suckerfeet as well as jointed legs and there are velvety spots or, spines on the segments. Pupation takes place in the soil. The imagines of both the observed Indian species are predaceous and very active:

Fig. 65.—PANORPA FURCATA. (*After Hardwicke.*)

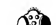

Fig. 66.—PANORPA FURCATA: HEAD. (*After Hardwicke.*)

they haunt shady places among bushes and under trees and attack comparatively large insects. These insects are uncommon and little is recorded about them. A pretty species marked with blue is common on the Western Ghauts in the rains, and a brown species is found in the Khasi Hills. Hardwicke describes a species from Nepal, figures of which are reproduced here. (Trans. Linn. Soc., XLV, p. 132.) It is common in the E. Himalayas, and has a resemblance to a large Ichneumonid. *Bittacus latipennis* Gerst. is described from Darjeeling (M. T. Vorpomn. XVI. p. 20, 1885). Probably others will be found when the family comes to be observed, and it will be possible to see how far their life history agrees with that outlined above.

HEMEROBIIDÆ.

Wings nearly equal in size, many-veined and held at an angle over the abdomen. The hind wing not folded. Antennæ well developed. Tarsi five-jointed. Larva with suctorial mandibles, pupa in a cocoon of silk.

This is a miscellaneous assemblage of easily recognised insects, united by the life history and larval trophi. The adults differ greatly in appearance, but form a distinct family. It is possible that the family will be confused with the *Sialidæ*, unless the student is familiar with the latter. The essential differentiating character is that in *Sialidæ* the wings are not densely reticulate, whereas they are so in *Hemerobiidæ* (except *Coniopteryx*).

As a rule, the different forms of *Hemerobiidæ* are so distinct that they can be recognised at sight, but the above is apparently the only true structural distinctive character in the imago.

As the habits of the seven sub-families are distinct, we propose to discuss each in turn.

Myrmeleoninæ.	Short knobbed antennæ.
Ascalaphinæ.	Long ,, ,,
Nemopterinæ.	Hind wings almost linear.
Mantispinæ.	Forelegs raptorial.
Hemerobiinæ.	Antennæ moniliform.
Chrysopinæ.	,, setaceous.
Coniopteryginæ.	Minute. Wings powdery.

Myrmeleoninæ. Ant-lions. Recognisable by the short clubbed antennæ; the wings are usually large and of equal size, often very much marked with brown and black.

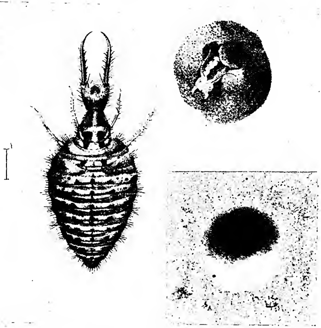

Fig. 67.—Myrmeleonid; larva, × 12; empty pupa case projecting from cocoon after emergence, × 12. Pit of the larva, × 1.

These large and somewhat ungainly insects have a wing span of three inches in the larger forms, the smaller of half that length. The colouring is sombre, brown predominating. The head is large and distinct with large compound eyes. The mouthparts are biting with long palps. The thorax is robust, often very hairy. The wings are long, of nearly equal size, with a great number of veins. The larger species have large red-brown or black blotches on the wings, the smaller have hyaline immaculate wings. The abdomen is long and slender, stretching between the long wings which are held in a sloping manner over the abdomen. The legs are comparatively short, robust and spiny, enabling the insect to cling tightly to plants. Males and females are similar in appearance, as a rule, the male sometimes distinct by the possession of two cerci.

The life history of the known species is uniform throughout the group. The eggs are laid in sand or earth; the larva that issues is flattened, the head large and flat, the thorax and abdomen stout. The head is elastically attached to the prothorax and has a large degree of motion. Projecting in front of the head are immense jaws, long and curved, which are made up of the true mandibles and maxillæ combined. The slender maxilla lies in a groove of the lower side of the mandible, and the two together form an imperfect tube, liquid ascending between the two structures into the mouth. This is an adaptation which enables the insect to suck the blood of its victims and food is taken in no other way. The larvæ live a free wandering life or live in pits in sand. The free-living ones lurk among vegetation and capture small running insects. They are a portion of the surface living insects which are so abundant in dense vegetation. Some species are common in damp localities, the imago found in long grass, the larvæ living a free life in the grass and capturing insects. The most familiar species live in pits in sand; the larva prepares these pits in a very ingenious manner. It commences by going round in a circle, moving backwards, its body making a furrow

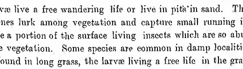

Fig. 68.—MYRMELEO SINGULARE.

in the soil; with its broad head it throws out sand, and by working steadily round in a spiral it gradually excavates a round pit, with sloping sides, and buries itself at the bottom. It then lies there motionless, its head at the bottom of the pit; should an unwary insect walk over the edge of the pit, the sloping sides impede its exit and the ant-lion throws sand at it by jerking its broad head. Sooner or later the insect comes within reach of the jaws and is seized, sucked out and the dried shell thrown out. Ants form a large part of its diet, as they are incessantly running over the soil, and the pits are apparently adapted to catch them; larger insects escape readily. This life is an interesting one and food appears to come only at long intervals. One might hold up this insect as a type of patience; they are able to endure long fasts and an occasional ant every week or so is apparently sufficient to keep captive specimens alive. They live only in dry sand and make new pits if occasion arises. Near houses these pits are common, and when rain comes, or when the rainy season sets in, the new pits are made under the lee of the house where rain will not wet the sand.

When the Pusa Laboratory was in course of erection, there were numerous pits in the dry sand spread over the newly floored verandahs; the reason they were there was apparently that the sand was dry, all the outside earth being soaked with the rains, but what food these insects got was not apparent as no insects were found there.

Pupation takes place in a cocoon in the sand or soil near the pit; the pupa has mandibles with which it can cut through the cocoon which consists of silk and particles of sand. It is noticeable that this silk is produced from the apex of the abdomen. The length of the life history is not known; imagos are found at all times from March to November. The imago flies clumsily but swiftly, and though nocturnal, is frequently seen flying in the day in long grass. An unpleasant odour is diffused from their bodies when they are handled, not an aromatic odour as in the *Hemiptera* but an unpleasant one, suggesting carrion. Light is an attraction and many can be caught in houses and at light. A number of species occur in India, but the usual darkness seems to shroud their nomenclature and classification. Two species of *Palpares*, seven of *Myrmeleo* and one of *Formicaleo* have been described from India by Rambur (1842) and Gerstacker (1893 and 1884). *Myrmeleon singulare*, Westw. is one of the commoner species, a very noticeable insect, figured and described in 1847 (Cab. Or. Ent., pl. XXIV, fig. 4). *M. pardalis* F. and *M. Punctatus* F. from the East Indies are figured in Donovan's Insects of India.

Ascalaphinæ—Differ from Myrmeleoninæ in having long antennæ, also clubbed.

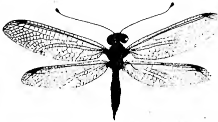

Fig. 69.—HELICOMITUS DICAX.

This small family is at once recognisable in the winged stage. The insects are of the same general structure as the *Myrmeleoninæ*, but with long antennæ held straight out from the head, clubbed at the tip. The wings are less elongated and only with few markings. The eyes are usually divided across by a distinct line as if the upper and lower halves functioned separately.

The life history differs in detail only from that of the *Myrmeleoninæ* so far as is known. The eggs were found laid on a lucerne stem, a number of little eggs in a row; each egg is cylindrical and truncate at the ends. Small active larvæ emerged, whose appearance is best learnt from the figure. They were fed on aphides, the aphides being seized in the sharp mandibles and sucked out. These larvæ died as the right food or conditions had not been found. (Others are being reared on a greater variety of insects). Other similar larvæ are found leading a free life in the fields; the thorax is broadly joined to the abdomen, the head not movably jointed to the thorax as in the ant-lions. A larva was found on the bark of a tree; it remained motionless on the bark without food for two months and all endeavours to feed it or rear it failed. An investigation into the habits of these larvæ in the field would yield interesting results, and it is possible that they play an important part in checking some insects. The imagines are found flying under trees or in grass and are apparently principally crepuscular in habit.

Westwood describes the following species of Ascalaphus (Cat. Or. Entom., 1847), and figures the first three :—

A. tessellatus (pl. XXXIV, fig. 1), *A. segmentator* (pl. XXXIV, fig. 2), *A. canifrons* (pl. XXXIV, fig. 3), *A. dentifer*, *A. angulatus*, *A. obscurus*.

No species had been previously described from India and ten have been since added. (Weele in Selys Collection, 1908).

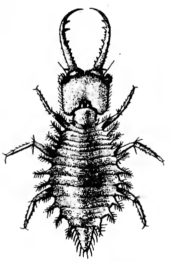

Fig. 70.—Ascalaphid larva, × 18.

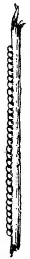

Fig. 71.—Eggs of Ascalaphid, × 2

Nemopterinæ.—The hind wings are long and very narrow, projecting backwards beyond the body.

A single species of this remarkable group is found abundantly in houses in India, flying about rooms in the dusk (fig. 72). We have observed it three years in succession in April and at no other time. The insect is a very graceful one, flying with a weak fluttering motion and hovering socially much as the mosquitoes do. A single larva of the type described as Nemopterous was found in a house in India; the characteristic is the immensely long thin neck carrying the round head and formidable jaws (fig. 73).

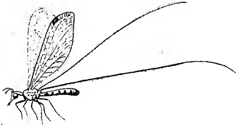

Fig. 72.—NEMOPTERID, × 3.

There is little reason to doubt that the larva of this Nemopterid lives in our houses and is probably predaceous on small forms of life; careful search in odd corners and dusty places will probably reveal the larva and clear up the life history of this insect. *Nemoptera filipennis*, Westw. is described and figured (Cab. Or. Entom., pl. XXXIV, fig. 6) from Central India.

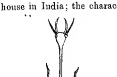

Fig. 73.—NEMOPTERID LARVA. (*After Roux.*)

Mantispinæ.—Forelegs predaceous after the manner of a Mantis. These obscure insects appear to be found but seldom in India, one species being known to occur in the plains. The imago has two pairs of hyaline wings, a rather slender body and the posterior legs fitted for walking. The forelegs have the tibia bent back upon the femur as in the *Mantidæ*.

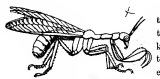
Fig. 74.—MANTISPA. × 2.

Nothing is known of the life history of our species; Brauer records that one European species lays stalked eggs, as do the *Hemerobiidæ*, and that the larva finds its way to the egg-mass of a spider and there feeds on the eggs and young spiders; it pupates in the web that contained the spider's eggs, and the pupa, when ready to transform, pierces its cocoon and the spider's web, the imago then emerging. *Glenurus pupillatus* Navas., *Mantispa rugicollis* Navas., and *M. Hamiltonella*. Westw. have been described from India, as also has *M. nodosa*, Westw. which occurs in Assam and is figured by Westwood (Cab. Or. Entom., pl. XXIV, fig. 7).

Hemerobiinæ.—The antennæ moniliform.

This sub-family includes two types of insects, of which some of each are known in India. The *Sisyrini* live as larvæ in freshwater sponges, and Annandale has recorded one as having been found in this situation in Calcutta. The student should consult Sharp's volume, where there is a good figure of the larva. *Osmylus perspicillaris*. Gerst., *O. langii* Macl., *O. lineaticollis* Macl., and *Dilar Hornei* Macl., are Indian species. The *Hemerobiini* are represented by one delicate brownish insect whose larva feeds on the cotton aphis. The life history differs only in detail from that of *Chrysopa* in the next sub-family; the eggs are laid on stalks; the larva is naked and feeds voraciously on aphides, sucking them out with its long mandibles. In this species pupation takes place under a very delicate web on a leaf. This insect is less common than its ally, the

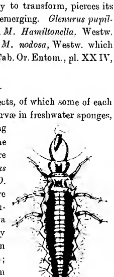
Fig. 75.—HEMEROBINE LARVA.

green Chrysopa, but may be found in cotton fields generally in the plains.

Chrysopinæ.—The antennæ filiform. One species of this group is common throughout the plains, a delicate green insect with shining eyes which diffuses an unpleasant odour on being handled. Here and there about the fields one sees little clusters of white eggs, each egg on a separate long slender stalk. (A Himalayan species lays the eggs so close together that the individual stalks coalesce and one finds a little bunch of eggs on a compound stalk). The clusters are everywhere,

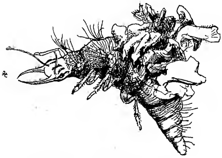

Fig. 76.—CHRYSOPA LARVA, WITH ITS COVERING OF SKINS. (F. M. H.).

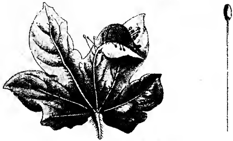

Fig. 77.—EGGS OF CHRYSOPA.

on weeds, on the cotton plant, on the ground, and if one watches carefully in the dusk, one may see a long green fly laying them some fifteen to twenty in a little cluster. In a few days (a little over a week), these eggs hatch, the thin shell bursting at the tip to allow the little creature to emerge; it sits on the egg shell on the top of the stalk till it has recovered from its cramped position in the egg and then runs off looking for aphis. It is a very active creature, with long legs, a slender body set with spines and a pair of long curved mandibles on the head. It is most voracious, catching the aphides in its hollow mandibles and sucking out the juice of their body. Having emptied the skin, it puts it on its back, where the long spines hold it, and eats the next aphis. This process continues indefinitely throughout the larval life of the little creature; it moves about with a large heap of the skins of its victims on its back, and it is no easy matter to make out what one has got hold of when one sees this extraordinary mass running over the cotton plant. At the periodical moult it gets rid of the accumulation of skins, which by no means includes those of all its victims and starts a fresh covering. Their voraciousness is very great and in captivity the single larva required on an average some 160 aphides for one day's food. This is

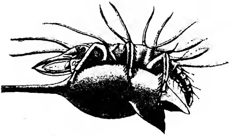

Fig. 78.—Egg and larva of Chrysopa.

Fig. 79.—Cocoon of Chrysopa.

probably not more than they eat when living freely on the plant; they feed very rapidly and voraciously and we can quite believe the number of victims in a day to be much larger. Finally, after eight days' feeding, its voraciousness is satisfied and it settles down in a quiet place to spin its cocoon and turn into the chrysalis. This is done on the plant and the chrysalis remains in it for about one month. The cocoon is a tough, white oval structure, built of silk, and when the fly is ready to come out, the top comes off as a neat little lid; there is probably a line of weakness in the cocoon when originally made, so that the top will come off neatly and allow the fly to emerge. The fly is a familiar insect with green head and body, bright golden eyes and long ungainly wings, which look much too big for it. One sees them flying about in the dusk or in the day time if disturbed, and like many other insects, the attraction of a lamp is usually too much for them. No Indian species appear to have been recorded.

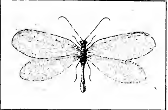
Fig. 80.—CHRYSOPA. × 2.

Coniopteryginæ.—Small delicate insects, in which the wings are covered with a white powdery secretion.

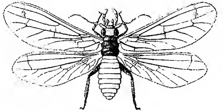
Fig. 81.—SPILOCORIS GUTTATA. (*From Enderlein.*)

These delicate insects are just known to occur in India, a few individuals having been captured flying and on a bair tree in Surat and among pine and deodar in Simla. An account of what is known of the life history will be found in Sharp's insects. They will be confused with *Aleurodidæ* if not carefully examined; the mouthparts are well developed with prominent palpi; the wing venation is comparatively complex and the tarsi five-jointed. The wings are white, the body red in one species.

Enderlein has listed the family (Genera Insectorum, 1908); no Indian species are recorded. He states that the larvæ, after feeding on Coccids, spin a web by means of anal spinnerets and rest under it till spring, when they pupate and emerge.

Collecting.—Special methods of collecting are not required in this family, but great care must be taken to preserve the specimens from damp as in all groups of Neuroptera. Myrmeleonides and Ascalaphides are on the wing once a year and come to lights. Nemopterids come out in houses at dusk and dance; the remainder must be sought for in their haunts. Any killing bottle is good, so long as it is quite dry. Good series of all species are required, and in this group there is very much biological work to be done before we can fully estimate the value of this family.

TRICHOPTERA.—*Caddis flies.*

Wings hairy, the hind wing larger, with a folded anal area. Coxæ long and contiguous. Antennæ long, tarsi five-jointed.

The family can be distinguished by the above characters with some doubt, since the hairiness of the wings is not always noticeable. They

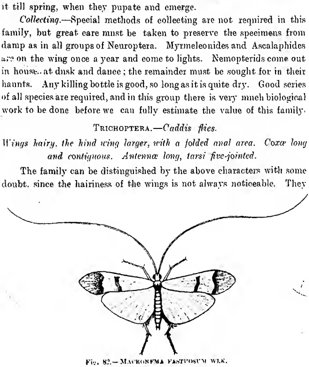

Fig. 82.—MACRONEMA FASTUOSUM WLK.
(*From Ulmer.*)

are rather delicate insects, moth-like in appearance, but with the wings sloped over the abdomen when at rest. The antennæ are long. We are aware of no observations on these insects in India, other than the descriptions of species. Their biology appears to be untouched. In general, the larvæ live in fresh water in cases, made of a great variety of materials, including silk, stones, vegetable matter, shells of molluscs, etc.; each species makes its special form of case, in which the larva lives. The larva is somewhat caterpillar-like, with a terminal pair of processes or hooks to fasten it to the case, with blood-gills of a variety of kinds to secure respiration. They are believed to be vegetarian, and while one at least is injurious to the "water-cress" grown in Europe, none are known to be injurious to India.

The student of this group should read the chapter in Sharp's Insects and the account in Miall's Aquatic Insects; it is to be hoped that the family will be investigated in India; the number of plain's species appears to be small, but very little is known and the group has not been studied. Wood-Mason recorded a species which produced 460 living young ones when artificially stimulated. Apparently this is the normal habit of this Caddisfly, which is provisionally named by him *Notanatolica vivipara* (Ann. Mag. Nat. Hist., 1890, 6 ser., Vol. VI, p. 189). Morton describes a *Hydroptilid* from the Khasis as *Ithytrichia violacea*, remarking that it is the largest of the sub-family with an expanse of 12-14 m.m. (E. M. M. 1902, p. 283). He also describes Khasi Rhyacophilids in Trans. Ent. Soc. London, 1900, p. 1. In all, some 61 species are recorded from India, Burma and Ceylon, the majority from the last locality, most of the remainder from the hills.

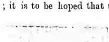

Fig. 83.—CADDIS LARVA, IN CASE. × 25. FROM BALSAM SLIDE.

The following are recorded from India by Ulmer (Zeitschr. Wiss. Insectenbiol, 1905, pp. 16, 68, 119, and Genera Insectorum, Trichoptera, 1907).

1. **Phryganeidæ**	1. *Neuronia maclachlani*, Wh. (India).
2. (Limnophilidæ).	
3. Sericostomatidæ	2. *Dinarthrodes armata*, Ulm. (Assam).
	3. *Dinarthrorum ferox*, Macl. (North India).
	4. *Dinarthrella destructor*, Ulm. (Darjeeling).
4. Leptoceridæ	5. *Notanatolica magna*, Wlk. (India, etc.).
	6. *Notanatolica vivipara*, W. M. (Calcutta).
	7. *Leptocerus indicus*, Wlk. (Bengal, its systematic position doubtful).
	8. *Setodes argentifera*, Macl. (North-Western India).
5. Hydropsychidæ	9. *Polymorphanismus nigricornis*, Wlk. (North India).
	10. *Aethaloptera sexpunctata*, Kol. (India).
	11. *Hydropsyche asiatica*, Ulm. (Sikkim).
	12. *Hydropsyche luctuosus*, Ulm. (Sikkim).
6. Polycentropidæ	13. *Plectronemia aurea*, Ulm. (Sikkim).
	14. *Plectronemia navasi*, Ulm. (Sikkim).
7. Philopotamidæ	15. *Dipseudopsis indica*, Macl. (India).
	16. *Stenopsyche griseipennis*. Macl. (India, etc.).
8. Rhyacophilidæ	17. *Rhyacophila anatina*, Nort. (Khasis).
	18. *Rhyacophila curvata*. Mort. (Khasis).
	19. *Rhyacophila inconspicua*, Mort. (Khasis).
	20. *Rhyacophila lanceolata*, Mort. (Khasis).
	21. *Rhyacophila scissa*, Mort. (Khasis).
	22. *Rhyacophila tecta*, Mort. (Khasis).
	23. *Rhyacophila naviculata*, Mort. (Trichinopoly).
9. Hydroptilidæ	24. *Ithytrichia violacea*. Mort. (Khasis).
	25. *Melanotrichia singularis*, Ulm. (India).

The *Trichoptera* are characteristic of moist temperate areas rather than of the moist or dry tropical areas and the student will scarcely find any species without search. None the less, it is probable that in the moister parts of India many remain to be found and this is true also of the hills. More species are recorded from Ceylon than from all India including the hills, and this is due partly to better collecting and to more attention having been paid to these insects there.

Note.—Since the above was in type, the Ascolaphid larvæ figured have been successfully kept alive and have passed through several instars; they are fed on small sluggish insects such as caterpillars, aphides and immature membracids; they are inactive by day resting pressed tightly on stones or earth, usually covered with particles of soil held by their spines.

The common hemopterid, which was obtained as usual in April, laid eggs in captivity, small oval bluish eggs, laid singly and concealed by adhering dust. They hatched to small white larvæ of the form shown in figure 73, but without the long neck which apparently develops in later instars. They cover themselves with dust and, in the absence of other food, prey upon each other. There can be no doubt that the larvæ occur in houses and other buildings and there is additional evidence that they are predaceous, probably upon Psocids (*atropos*) and other small forms of insect life, their long necks probably assisting them to obtain their prey in cracks and chinks.

HYMENOPTERA.

Two pairs of wings of almost equal size, hyaline and with few veins. The antennæ simple, straight or elbowed. The mouthparts mandibulate, the labium and maxillæ formed in some cases into a lapping tongue. The thorax complex, the parts accurately co-adapted to form a rigid whole. An extrusible ovipositor is present. Metamorphosis complex, the larva freeliving or, more usually, dependent for food on a host or on the parent and in this case a white apodous grub. In both the latter the imaginal life is the active period, usually of long duration. The order includes herbivorous insects, feeding in or on plants, parasites in insects, stinging predators feeding their young on paralysed insects and spiders, and social or solitary insects deriving their food from flowers, from waste matter (scavengers) or from living insects.

The sawflies, gallflies, ichneumons, cuckoo-wasps, bees, ants and wasps which make up this order are readily recognised in the field: the order is a very large one, with a great number of known species, and perhaps a greater number of undescribed species than any order except Diptera. It includes insects of the very highest importance to agriculture, and some of great economic value but few that are destructive to crops or merchandise.

The classification of this large order is simple, and though authors do not agree as to the details, the broad lines are generally accepted. Ashmead has revised the whole classification and introduced a new nomenclature. but, while this is accepted in America, it is not that accepted in Europe and differs from that still adhered to in England. We must here follow the Fauna of India. The order is divided into *Sessiliventres*, with the abdomen broadly attached to the thorax, and *Petiolata* with the abdomen connected to the thorax by a petiole. The *Sessiliventres* include only three families of phytophagous insects, which are borers in plants or feed on leaves. The *Petiolata* includes the remaining 24 families. which fall into three series :—The *Parasitica*, with divided trochanter and extruded ovipositor, the *Tubulifera* and *Aculeata* with retrusible ovipositor and single trochanter, the former with three to five visible ventral segments and an ovipositor, the latter with the abdomen of more than five visible ventral segments and a sting.

The *Aculeata* again fall into four series, the *Anthophila* with plumose hairs and dilated hind tarsi, the *Diploptera* with forewing longitudinally folded in repose, the *Heterogyna* with the basal one or two segments formed into nodes, and the *Fossores* without any of these characters. The classification of the order falls as in the following table :—

SESSILIVENTRES.			(Cephidæ).
(PHYTOPHAGA).			Siricidæ.
			Tenthredinidæ.
PETIOLATA.	PARASITICA.		Cynipidæ.
			Proctotrypidæ.
			Chalcidæ.
			Dryinidæ.
			Ichneumonidæ.
			Braconidæ.
			Stephanidæ.
			(Megalyridæ).
			Evaniidæ.
			(Pelecinidæ).
			Trigonalidæ.
	TUBULIFERA.		Chrysidæ.
	ACULEATA	FOSSORES.	Mutillidæ.
			Thynnidæ.
			Scoliidæ.
			(Sapygidæ).
			Pompilidæ.
			Sphegidæ.
		DIPLOPTERA.	Eumenidæ.
			Vespidæ.
			(Masaridæ).
		ANTHOPHILA.	Colletidæ.
			Apidæ.
		HETEROGYNA.	Formicidæ.

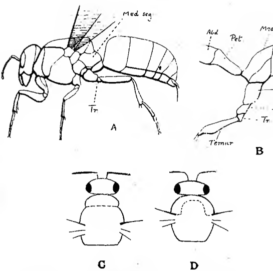

Fig. 84—A. VESPA MAGNIFICA, TO SHOW MEDIAN SEGMENT AND SINGLE TROCHANTER (TR). B. BRACONID TO SHOW JUNCTION OF THORAX AND ABDOMEN. PET.-PETIOLE, MED. SEG-MEDIAN SEGMENT. TR. 1, TR. 2, THE DOUBLE TROCHANTER. C. THORAX OF SPHEGID TO SHOW COLLAR-LIKE PROTHORAX. D. DITTO. OF POMPILID TO SHOW PROTHORAX REACHING THE TEGULÆ.

There is a very extensive literature on this group. The *Sessiliventres* and *Parasitica* have been largely listed in Genera Insectorum and the *Ichneumonidæ* and *Braconidæ* are being monographed in the Fauna of India shortly. The *Tubulifera* and *Aculeata* are already monographed in the Fauna of India but the student will find a large number of species since described by Cameron, Nurse and others.

It is at present useless to attempt to grapple with the *Parasitica*, and our account below must, in the absence of the Fauna volume, be meagre in the extreme. Collections in this group are badly wanted and there is here a very large field for collecting and research, specially in tropical India. In the *Aculeata*, the pioneer work of listing and describing species is largely done, though new species still appear, and the next step is to study the habits and life-histories. The student will note that we follow the order and nomenclature of Bingham's Fauna of India, rather than that of continental authors as is done by Nurse and Cameron, and as may be most easily seen in Genera Insectorum.

HYMENOPTERA SESSILIVENTRES

SIRICIDÆ—(including *Oryssidæ*).

A small family distinct from other families by the characters of the thorax and venation, as well as by the larval habits. The larvæ are borers in wood and have three pairs of stumpy legs on the thorax, a process at the end of the abdomen. The imagines are conspicuous insects, large and brightly coloured, the female with sharp ovipositor. They are wholly forest insects and confined in India to hilly forest tracts. The recorded Indian species include *Xiphydria* (3 spp.), *Sirex* (1 sp.), *Paururus* (1 sp.), and *Tremex* (3 spp.). None are likely to be found in tropical India.

TENTHREDINIDÆ—*Sawflies.*

The pronotum small; two spurs to the tibia. The female with a saw, usually concealed. The larva leaf-eating, caterpillar-like, with more than five pairs of sucker feet.

The sawflies are easily recognizable from other *Hymenoptera*, the abdomen being broadly united with the thorax, the pronotum small and visible principally at the sides, the female without an exserted ovipositor and the anterior tarsi with two spurs. They are moderate-sized insects, of bright colours, the common plains species less than one-third of an inch long. The head is distinct, with short antennæ, simple and compound eyes and the usual biting mouthparts. The thorax and abdomen are robust, the wings short and often smoky or coloured. The most striking structure is the female ovipositor or "saw," with which she cuts leaves in which to lay her eggs. This is concealed except when in use and requires to be dissected out.

The life-history is, in general features, similar to that of the *Lepidoptera*. The larva is a caterpillar-like creature with three pairs of thoracic legs and from six to eight pairs of prolegs without hooks on the

PLATE IX.—ATHALIA PROXIMA.

THE MUSTARD SAWFLY.

Fig. 1. Young larva.
,, 2. Half-grown larva.
,, 3. Full-grown larva.
,, 4. Larva feeding on mustard leaf.
,, 5. Pupa, dorsal aspect.
,, 6. Pupa, ventral aspect.
,, 7. Imago.
,, 8. Cluster of Cocoons.
,, 9. Single Cocoon.
,, 10. Parasite.

(Reprinted from Memoirs, Agricultural Department for India, Entomology, Vol. I, No. 6.)

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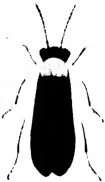

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abdominal segments. This character at once distinguishes it as no *Lepidopterous* larva has more than five pairs of prolegs. The larva lives openly, feeding on leaves; in some the hind end of the abdomen is more flexible and tapering, and is twisted round in a characteristic manner to give support to the insect. The larva of *Athalia proxima*, Klug., the commonest plains species, feeds on mustard and Cruciferæ generally; its life-history is described elsewhere (Mem. Agric. Dept., India, Entom. I, No. 6). It is undoubtedly an immigrant from the hills which has adapted itself to life in tropical India by a prolonged period of rest during the hot months. The pupa is concealed in a cocoon between leaves or in the ground. It is recorded that *parthenogenesis* occurs in this family; this does not appear to be the case with *A. proxima*, where both sexes occur and coupling takes place normally.

The family is a large one with over 2,400 species described of which 90 are known from India, being mainly species collected in Assam, Burma and Simla. The hill fauna is very much larger than that of the plains but the large number described is partly due to the fact that this group has been collected there and has not been worked at in the plains. Cameron has described the majority of the species within the last ten years. Only two species are known from the plains of which *Athalia proxima*, Klug., alone has been reared. (Plate IX.) The most recent catalogue is that of Konow in *Genera Insectorum*.

HYMENOPTERA PARASITICA.

From practically every herbivorous insect, as from many others, we rear parasites belonging to this group. From a single species we may get one or more egg parasites, and one or more larval parasites; we find also that these parasites have their parasites (called *hyperparasites* as they are parasites on parasites). Thus from one species we may rear several species of parasitic hymenoptera. It will be seen that this group is one of vast extent and number; it is also one whose study has not attracted sufficient attention; Indian forms have been described (in a great variety of somewhat inaccessible publications) by Cameron and others from specimens collected in the hills; we have reared abundant species which will require much time for identification and we are thus in a position of having a great mass of material which has not been worked at and we cannot attempt to give any satisfactory account of this great group. In no branch of entomology is study so much required and no branch is likely to give results of greater economic value. Parasitic Hymenoptera are the greatest checks on insect increase and their work is of the utmost importance; this has been recognised elsewhere and the study of Parasitic Hymenoptera should advance when more encouragement is given to Entomology generally. As it is we are unable to do anything to assist these insects save in very special cases; when it was learnt that the parasites of the Indian bollworm had been destroyed by cold, and these were reintroduced from places not affected by the coid, the first step to the utilisation of parasitic insects was taken in India: but this was a special case and until we know our parasites, we cannot expect to be able to make progress in this branch of entomology.

CYNIPIDÆ.—*Gall-wasps.*

Small to minute insects, the forewing with no stigma and not more than five closed cells, the hindwing with two or three nervures: the antennæ are straight with less than 16 joints. The pronotum reaches the insertion of the forewings.

Whilst the habits of the family are of great interest, almost none are described from our region and the habits of these are unknown. One species (*Onychia striolata*, Cam.) from Bengal will, if it shares the habits of the rest of the genus, be a parasite on a *Dipterous* insect. Others are known to inhabit galls. Cameron has described *Callirhytis semicarpifoliæ* as being reared from an acorn (*Quercus semicarpifolia*) collected in the North-West Himalayas. (Entomologist, 1902, 38.)

In general, the *Cynipidæ* are either (1) inhabitants of galls or other portions of plant tissues, (2) guests of the above gall-inhabiting species or (3) parasites on other insects. Taking first the gall-insect, it may be remembered that many other insects make galls and that not every gall is due to the work of the *Cynipid*; also that a gall may contain the *Cynipid* that caused it or either guests or parasites. A number of very similar insects may therefore be reared from the same galls and it is no easy matter to sort them out. It is very much to be desired that the study of galls may be taken up in India, and with it, the study of the relations of the insects inhabiting such galls. Galls abound even in the plains and those on the mango tree alone will give ample scope for investigation. Having cleared them up, the study of galls on other trees in the plains and then in the forests and hills may be expected to produce much that is new and second in interest to no other branch of insect bionomics.

An excellent account of some of the features of this group is contained in Sharp's Insects. The student is referred to this, and it is needless to here reproduce a similar general account of a group of which almost nothing is known in India.

GALLS.

There are a number of insects, which live in the tissues of plants and whose activities produce an alteration of the structure of the plant, an unusual growth of tissue taking place, leading to the formation of a "gall." Such galls are easily recognisable as quite distinct bodies, associated always with a particular insect and for each species of inhabitant assuming a peculiar form.

Obviously this is a clearly distinct form of injury to the plant from that caused by an ordinary boring or leaf-eating insect, in which there is no growth of tissue except in so far as to heal the wound caused, and where the damage done is limited to the effect produced solely by the destruction of so much tissue.

As a rule, the connected insect is in the gall, not necessarily in the fully developed gall but in it at some stage of its growth; put very broadly, the parent or the actual insect stimulates the tissues to an abnormal growth in which the gall insect lives; the precise nature of this stimulus is not known for any of our galls but may be either poison or some agent introduced by the parent when laying eggs, or it may be a chemical or mechanical stimulus produced by the larval gall-insect inside the tissues. The growth of a gall does not always terminate with the emergence of the inhabiting insect and in some instances very large woody structures are produced on trees after the original gall-insect has emerged.

Elsewhere, the Cynipidæ are the especial gall-insects either inhabiting the gall by right or as inquilines (guests). The larvæ of *Nematus* are said to form galls and insects of this family (*Tenthredinidæ*), will possibly be found as gall inhabitants in India also. The Fig Insects of the family *Chalcidæ* are probably gall producers, living in special gall flowers in the fig. An abnormal *Buprestid* (Ethon) is known to live in a gall and some of the *Curculionidæ* also produce galls. Among *Lepidoptera*, a few *Tineidæ* are known, and the transition from a boring larva to one that causes gall-formations is not a very wide one. *Cecidomyiids* are well known among the *Diptera* and are found in India behaving in this manner. Thrips (*Thysanoptera*) causes galls, as also do the three groups of *Homoptera*, the *Psyllidæ*, *Aphidæ* and *Coccidæ*: *Psyllids* are known to live in galls in India but do not appear to have been studied. Several have been reared from galls on leaves in India and it would appear that they are the commonest gall-insects. In Australia, a special division of *Coccidæ* (*Brachyscelids*) are inhabitants of galls. In India *Dactylopius nipæ* Mask. produces what is practically a gall, a swelling and distortion of the tissues of the plant, due to the presence of the insect; these are found on some varieties of cotton, on Hibiscus and on mulberry. We have indicated these families as being those in which gall-insects are known and in which they may be expected also in this country. Galls are not easy to rear in "captivity," since the removal of the gall from the growing plant interferes with nutrition, and moulds are a great trouble; gall-insects are also not quick in development and it is probable that success will be obtained only by breeding on the plant or by patient observation. We figure some galls as well as the insects causing them (see under *Cecidomyiidæ* and *Psyllidæ* below). The student should see Kieffer's paper on Gall-insects of Bengal (Ann. Soc. Bruxelles XXIX, p. 133, 1905).

PROCTOTRYPIDÆ.

Small insects, the prothorax reaching back to the tegulæ, with few nervures in the wings, the antennæ straight.

The classification of the parasitic *Hymenoptera* is as yet insufficiently understood and with such vast families to deal with, it is, without going far more deeply into the subject than we here can, impossible to give characters by which to recognise any '*Proctotrypid.* They are essentially small parasitic *Hymenoptera*, with the above general characters; they differ from the *Chalcidæ* in fairly characteristic details, but include some insects very difficult to place if one has not a very thorough grasp of these families. These little insects exhibit great variety in structure. The ovipositor is a continuation of the end of the body. Many are of beautiful metallic colours, the body hard, like that of *Chrysidæ.*

The life is so far as known, wholly parasitic, though the habits of not many species are known. The Indian species reared are from insect eggs, one from a dipterous larva and one from a beetle larva. It is certain that a great number will be reared when more attention is paid to this group. The family is a very large one with numerous subdivisions. Judging from the number of undescribed species found or reared, the plains' species of India are little known. Dalla Torre's catalogue gives some five Indian species, besides a number more from Ceylon, but this number is an extremely small part of what would be known were the group to be collected: a great number of these as of other parasitic Hymenoptera are being found or reared and the family is probably an extremely important one.

Scelio acte, Wlk., and *Epyris orientalis*, Cam., are recorded as well as *Platygaster oryzæ*, Cam., bred from the maggots of *Cecidomyia oryzæ*, W. M. A species of *Scelio* attacks the eggs of the Bombay Locust, *Acridium succinctum*, Linn.; *Hadronotus sp.* and *Telenomus sp.* were reared from insect eggs and *Telenomus sp.* from the eggs of *Scirpophaga auriflua*, Zell., a *Pyralid* moth. *Scelio* (Homalotylus) *terminalis*, Say., is a parasite upon the larvæ of *Chilomenes sexmaculata*, Fabr.

THE SIZE OF INSECTS.

We are told that on other planets, man might be very much larger than he is on earth on account of the less force of gravity due to the smaller bulk of the planet. That is, the Mammoth or some prehistoric reptile represents the maximum size attainable on earth simply because the bones requisite to support a larger animal and to bear the muscular strains set up in moving it could not, with the material of which bones are constructed, exist. Gravity and the tensile strength of the material used in making the skeletons of animals thus puts a limit at one extreme. On the other extreme is another limit in the size occupied by a sufficient aggregation of molecules to carry on the complex reactions of physical life, a limit which possibly admits of the existence of forms of life smaller than can be perceived by our present methods; at any rate, there are organisms visible only under a magnification of thousands of diameters.

Between these extremes lie our insects; the smallest are less than a millimetre in length: the largest moth has a wing span of twelve inches, the biggest beetle a length of over half this and the bulk of our insects are between three and one-tenth of an inch long and between five and a fifth of an inch across the expanded wings.

Probably the essential feature in insect anatomy that has limited them in size is the chitinous integument: an insect has no bones, it has no separate internal skeleton round which the soft tissues can be grouped and which can give a central support to muscles and connective tissue; there is only an external integument, with processes internally, and the tissues take their attachment from this and are packed away inside it. There is further the delicate tracheal system, probably capable only of a certain amount of compression and thus limiting the amount of stress that can be set up by muscular action. Another point is that the chitinous integument is not, except in the adult stage, a permanent one; it is shed and this puts a very definite limit probably upon the size to which it can be produced.

Other factors probably are the very great specialization insects display; we may imagine a caterpillar, if omnivorous and without enemies, growing to the limit of the size that its chitinous legs, and prolegs could bear; it might perhaps be six feet long and a foot high, walking along like a vast worm and browsing happily in the pasture. But there are no omnivorous caterpillars (plants protect themselves too well with poisons and other devices), the vast number and variety of species are correlated with great specialisation and whether from the limitations of chitin, or from the difficulties of metamorphosis, such vast creatures do not exist.

Possibly insects are dominant because they are small, reproduction can be quick and vast, an egg can contain enough food to produce an active self-supporting larva; the difficulties of viviparism are avoided and the mother need not live over to care for her young. When the seasons are unfavourable, the female waits with her store of undeveloped eggs till the season is favourable. Above all, where there is one vast animal like a cow, conspicuous and slow breeding, you may have, in equal bulk, a horde of scattered insects, ready to concentrate themselves on one point but capable, in times of stress, of diffusion over wide areas and in inappreciable amount. It is the case of the fly which eats the carcase quicker than the lion, because the concentrated effort and increase of a thousand small creatures outweighs the efforts of the one large creature a thousand times their size.

The insect, with the lion, endures times of starvation but of a thousand, perhaps, ten insects survive, whereas the one lion dying leaves none. So that taking lives as units, the small insect is better off and it may be that in the very limitations of chitin and metamorphosis has lain its success, since strivings after mere bulk have been vain where natural effort at increase, with multiplication of species and function, has enabled the insect to overrun and dominate the earth.

DRYINIDÆ.

Female with the foreleg modified to form a pincer.

A family of nearly 200 species of small insects, usually included in *Proctotrypidæ*, and distinguished by the fact that the fore tarsus is modified in the female to form a pincer.

This modification of the foreleg is connected with the habits of the insect; according to Kieffer, the female seizes the nymph of the *Homopterous* insect she attacks by means of the pincers, and lays one or two eggs in its abdomen; the resulting larva develops, emerges and pupates outside, the *Homopterous* nymph dying. Three species only are known from India: *Dryinus trifasciatus*, Kieff., *Prodryinus bifasciatus*, Soy., and *Gonatopus maurus*, Kieffer.

One has been reared from the Fulgorid *Pyrilla aberrans*, Wlk., the larva living in the nymph and emerging to produce a small white cocoon on the leaf of the cane plant. (Fig. 86.)

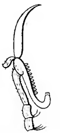

Fig. 85—ANTERIOR TARSAL JOINTS OF GONATOPUS GRACILIS. (*From Kieffer.*)

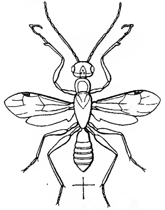

Fig. 87—DRYINUS FORMICARIUS. (*From Kieffer.*)

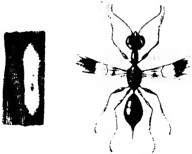

Fig. 86. DRYINID PARASITE OF PYRILLA ABERRANS × 9 AND ITS COCOON ON A LEAF. × 2.

CHALCIDÆ.

Small insects, the antennæ elbowed, the wings with one vein, the protonum not reaching the tegulæ.

This very large family is most readily distinguished by the elbowed antennæ and single-veined wings. Many are of characteristic form and are readily recognisable as *Chalcids* in the field. The colours are sombre, though black and yellow is a frequent combination. They are nearly all small; though *Leucospis* measures nearly half an inch in length, less than a quarter of an inch is a more usual size and some are so small as to be microscopic and not really visible to the unaided eye. The head is well developed, with elbowed antennæ, large eyes and the usual mouthparts. The thorax is compact giving great powers of flight to the tiny insect. The wings are hyaline with a single vein in the forewing. The abdomen is hard and in the female bears an ovipositor. Legs are well developed and the little insect walks and flies actively. The hind femur is frequently very much swollen, the narrow tibia fitting closely to it.

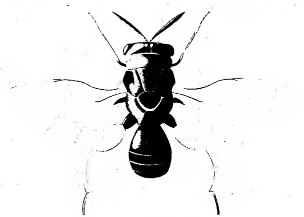

Fig. 88—CHALCIS CRICULÆ, MUCH MAGNIFIED.

The details of the life history of the group as a whole are very varied but most are parasites in eggs, larvæ or pupæ of almost all groups of insects including the *Hymenoptera;* some are hyperparasites, *i.e.,* lay their eggs in the bodies of parasitic larvæ which are already in the bodies of other insects; others are found in galls, as parasites; a few are fig insects living in peculiar gall-like structures in the fruit of wild figs; the greater number are parasites purely, and though the details of their life history would probably be of great interest if we knew them, practically nothing is known and we are probably sufficiently accurate in estimating the family as an important one owing to its rôle of general insect parasite.

The life history of no Indian species has really been studied and the utmost we know in most cases is that the imagines have been reared from particular insects. There are abundant points of great interest in the lives of these tiny insects; how do the imagines live when their host is not available; how do they hibernate, on what do they feed, when do they fly? How does the larva manage inside the body of a caterpillar and how does it get its air or dispose of its excreta, or moult? What is going on inside a caterpillar when there are perhaps twenty larvæ in it or as in some cases there are over 600? What are the details of the moults of the hyperparasites? One could continue enumerating points on which practically nothing is known at all, and absolutely nothing in India. Dalla Torre's catalogue enumerates about thirty species from our region; Cameron has added others (Jo. Bo. Nat. Hist. Soc., XVII, 578, etc.), a very large number have been and will be added to this, and it would be in no way surprising if *Chalcidæ* were found to be the family of which the greatest number of species occur in India.

The identification of these numerous forms, principally unclassified and undetermined, is possible only when one studies this family alone. It is then useless to do more than mention a few common species as examples of *Chalcidæ.* The following species and their hosts are known in India :—

Pentarthrum (Trichogramma) sp. is a tiny species reared from the eggs of *Chilo simplex,* Butl., the moth-borer of cane. A very high percentage of the eggs of this moth are infested, and the parasite is a very valuable check. *Tetrastichus sp.* is reared from *Chilo auricilia,* Ddgn., and is probably in itself a hyperparasite upon the *Braconid,* *Apanteles chilonis*. The imagines of the former emerge directly from the pupa of the caterpillar, not making an external cocoon, whilst the *Apanteles* larvæ, if not parasitised, emerge as full-grown larvæ and make white cocoons outside their host.

Syntomosphyrum (Cirrospilus) *sp.* is reared from pupæ of *Chilomenes sexmaculata*, F., a Ladybird beetle, where it is possibly a hyperparasite of *Scelio* (Homalotylus) *terminalis*, Say., which parasitises this beetle grub. *S. esurus*, Ry., has been reared from the cotton aphis (*Aphis gossypii*, Glov.) in which it is possibly a hyperparasite of *Trioxys sp.*, a Braconid parasite. *Omphale sp.* is a small insect of which 77 were reared from the grub of a Cotton Stem Borer, *Sphenoptera gossypii*, Kerr. It is probably a hyperparasite on the true parasite of this beetle grub. *Pteromalus oryzæ*, Cam., is a parasite of the grub of the rice weevil *Calandra oryzae*, L., and keeps this voracious pest in check. (I. M. N.) *Aphelinus theæ*, Cam., is recorded as a parasite of the scale insect, *Aspidiotus theæ*, Mask., on tea in the Kangra Valley. (I. M. N.) A species near to *Sycoryctes philippinensis*, Ashm., has been reared from the fruits of the pipal (*Ficus religiosa*) in India, and with it *Goniogaster*, (Idarnes) *stabilis*, Wlk., and *Sycophila decatonioides*, Wlk., which are parasitic upon it.

The following species are also recorded as having been reared from the figs of *Ficus indica* (? meant for *Ficus bengalensis*, the banyan tree) :—*Eupristina masoni*, Saund.; *Sycobia bethyloides*, Westd. : *Walkerella temeraria*, Westd.; *Sycobiella Saundersi*, Westd. : *Sycoscapta insignis*, Saund.; *Sycoscaptella affinis*, Westd. ; *Micranisa* (Idarnes) *pteromaloides*, Wlk.

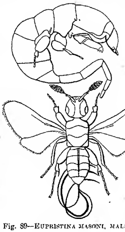

Fig. 89—EUPRISTINA MASONI, MALE ABOVE, FEMALE BELOW.
(*From Westwood.*)

Walker also described *Sycophila megastigmoides* and Mayr described *Sycophaga breviventris* from figs in India. The student should consult the original papers:—Westwood, T. E. S., London, 1840, Vol. II, p. 214; Westwood and Saunders, loc. cit., London, 1883, pp. 1, 29, 375, 383; Westwood, loc. cit., 1882, 47; Mayr, Mittheilungen Zool. Stat. Neapel, III, 1882.

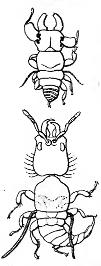

Fig. 90—SYCOBIELLA SAUNDERSI SYCOSCAPTA INSIGNIS MALE. (*From Westwood.*)

These fig insects have been the subject of prolonged investigation in Europe and South America, and an unknown species which attacks *Ficus roxburghii* in Calcutta is discussed by Cunningham in an appendix to Volume I, of the Annals of the Botanic Garden, Calcutta. Cunningham finds that there are two crops of fruits yearly, some trees having receptacles containing gall flowers and males, others containing female flowers; in the gall flowers, which are peculiar structures, the fig insect lays its eggs, the larvæ living in the gall and eventually emerging in the winged condition. On emergence they fly, couple, and the females endeavour to lay eggs. In searching for the gall flowers, the females enter the receptacles. including those containing female flowers, and endeavour to deposit eggs in the female flowers. As a result the enormous numbers of embryos in each receptacle develop, as if they were fertilised. The inference, naturally, is that the female insects carry pollen from the male flowers. but Cunningham concludes that this is not the case and that the female embryos develop parthenogenetically but only after the irritation produced by the attempts of the female fig insects to lay eggs in these flowers. The fig insect then plays the part of an irritant agent. producing effects equivalent to fertilisation and the fig plant produces. on behalf of the insect. special "flowers" in which the insect lays its eggs. The *Chalcid* then in this case is simply a gall insect, as the *Cynipidæ* are.

Connected with these fig insects are parasites, insects very closely allied and which lay their eggs in the larvæ of the fig insects in the fig gall flowers; Cunningham does not appear to have been aware of this fact or to have known what fig insects he was dealing with and this is to be regretted as his conclusions may require to be vitally modified. (This applies equally to the same author's chapter in that popular but inaccurate work 'Pains and Pleasures of Life in Bengal.') Fig insects seem to be very abundant in India, and a great number of the wild figs produce large crops of them. The question has a special interest in view of the fact that the true fig is stated to produce the best figs only when its fig insect *Blastophaga psenes*, Low., is present: for this purpose a wild fig has to be cultivated with the cultivated fig to yield Blastophaga; so necessary is this considered that the wild fig (Capri fig) has been introduced to California and South Africa with the *Blastophaga*, in order to give the figs there grown the proper conditions for full development, though entomologists are not yet agreed as to the part played by the insect.

That the fruits of our common fig trees (the pipal, banyan, pakur, gular, &c.) are constantly infested with fig insects can be readily ascertained by examination, various caterpillars, weevils, flies, &c., also occurring in them, but the respective parts played by these insects, their mode of life and their relations to the tree are practically unknown and offer a very fertile field for inquiry. We figure from Westwood some of the insects obtained from figs in India; the problem is one of great complexity and interest, attention has been drawn to it more than once in the Indian press from the economic aspect since large quantities of fruit are constantly "destroyed" by these insects, but it is doubtful if any means can be devised of checking them and were it done, it is uncertain what would be the effect upon the production of fruit.

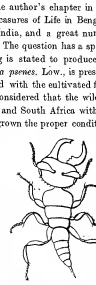

Fig. 91—WALKERELLA TEMERARIA. (*From Westwood.*)

Podagrion minutum, Ashm., was reared from the egg mass of a mantis, the female with a long ovipositor many times her own length for lay-

laying her eggs. *Chalcis criculæ*, Kohl. (fig. 88) is recorded as a parasite of *Cricula trifenestrata*, Mo. a Saturniid Moth. (I. M. N. I., pl. V). *C. euplœæ*, Ho., is also recorded as a caterpillar parasite. The number and importance of *Chalcidæ*. like the other *Hymenoptera Parasitica*. cannot easily be estimated. There are probably an enormous number of species in India, some widespread, many probably confined to this area. To the systematist as to the biologist they offer a wide field of research, and it is to be hoped that a really thorough investigation into the economy of at least one species may be made, as well as an investigation into the identity and hosts of our common crop pest-destroying species.

ICHNEUMONIDÆ.

Wings with two recurrent nervures and two or three cubital cells. Antennæ not elbowed.

This is a very large group of insects, clearly separate from *Chalcidæ* by the greater number of veins and cells, from *Braconidæ* by the venation. They are. as a rule, larger insects, the antennæ not elbowed, the legs moderately long, the body slender. The female has an ovipositor which is often long and conspicuous; males are destitute of any ovipositor or similar organ and are generally similar to the females. The colours are mainly warning, black and yellow, reddish yellow and similar bright colours predominating.

The *Ichneumonidæ* are a very large family, with a great number of species. These species are of limited distribution, confined to distinct areas and the Indian forms are, so far as known, confined to this geographical region. The number of described Indian species is over 200 but most are from the hills and but few have been reared.

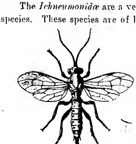

FIG. 92—PIMPLA PREDATOR, FABR. × 2.

Limnerium sp. has been reared from the larva of a *Plusia*: *Pimpla punctator*, L., is a common insect, yellow with black markings, bred from several of the wild silk producing insects (*Saturniidæ*). *P. predator*, F., was reared from *Scirpophaga auriflua*, Zell. (I. M. N. V., p. 178.)

The family is divided into five sub-families; of the *Ichneumoninæ*, up to 1904, 119 species had been described from India, largely from the Khasia hills by Cameron and others have been added since. In the *Cryptinæ*, 84 species are listed up to 1908 (*Schmiedeknecht*, Genera Insectorum), mainly Cameron's Khasia hill species. The same author lists 59 species of *Pimplinæ* (1907), including the remarkable forest species *Rhyssa* and *Ephialtes*, allied to *Thalessa*. In the *Tryphoninæ*, Dalla Torre (1900) lists five Indian species, and in the *Ophioninæ* Szepligetti (1905) lists twenty-one.

Nothing is on record as to the hosts of these species and the forms occurring in India generally are practically unknown.

BRACONIDÆ.

The forewings with one recurrent nervure and three or four cubital cells as a rule. Antennæ not elbowed, abdomen not inserted on apex of median segment.

These are closely allied to the *Ichneumonidæ* but in general distinguished by the venation of the forewing. There is an extra cubital cell and but one recurrent nervure. The colours are bright, probably generally warning, and aided by the bright colour of the forewings in some cases. In size they vary from small to moderate-sized insects with a wing span of over one inch. The head is large, distinct, with moderately long antennæ, which are probably very delicate sense organs. The thorax is compact, bearing the moderately large wings: the abdomen is long and slender. The general form varies very greatly, probably in relation to the stinging habits of the female, and some are greatly elongate or otherwise bizarre in appearance. The female has an ovipositor which may extend to a considerable length; the males

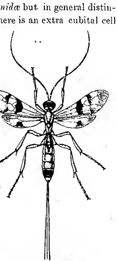

Fig. 93—BRACON NICEVILLEI, FEMALE. × 2.

are closely similar to the females in general appearance, but without ovipositor.

The life history is, so far as known, parasitic, the larvæ living at the expense of other insects, usually *Lepidoptera*. In spite of the multiplicity of species and their great importance, little is known of the life history of these insects beyond the fact of their parasitism. As in other parasitic insects, there are points about the details of the larval life which are shrouded in darkness and deserve further study. The remarks made above as to the general life of these parasitic hymenoptera apply to this family.

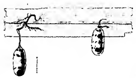
Fig. 94—PUPA CASES OF A BRACONID, SUSPENDED FROM A LEAF.

This large family has representatives in every part of the globe, and though the Indian species are probably little known, 57 species are listed as Indian by Szepligetti.

Bracon is a large genus with nearly thirty Indian species largely Himalayan. Of these, *B. nicevillei*, Bingh., is parasitic on the larva of *Scirpophaga auriflua*, Zell. and other insects. This species is so named in honour of Mr. L. de Niceville who first reared it in Behar. (Indian Museum Notes, Vol. V, No. 3, p. 177.) It is a large insect, the wings orange and black (fig. 93), very conspicuous, and a valuable check upon this pest. The female has a long ovipositor with which to penetrate the cane and reach the larva. Little is known of other species, which have been principally collected in the hills. A number of plains species have been reared and the more important of these are the following:—*Aphidius avenæ*, Hal., is parasitic upon the wheat aphis

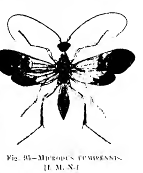
Fig. 95—MICRODUS TUMIPENNIS. (I. M. N.)

(*Macrosiphum granarium*, Kby), *Trioxys sp.* has been reared from the cotton aphis (*Aphis gossypii*, Glov.). *Microdus fumipennis*, Cam. fig. 95) and *M. tuberculatus*, Cam., are recorded as parasites of the castor caterpillar (*Trabala vishnu*). (Ind. Mus. Notes, Vol. V. p. 107.)

Apanteles glomeratus, L., is from a caterpillar attacking white gourd. (? *Sphenarches caffer*, Zell.) *A. chilonis* is parasitic upon the larva of *Chilo auricilia*, Ddgn., which attacks cane. *A.* (Urogaster) *indicus* is parasitic upon the cotton bud caterpillar (*Phycita infusella*, Meyr.) and *A. depressariæ*, on *Gelechia gossypiella*, the pink bollworm. *Apanteles* commonly pupate in very noticeable white cocoons. openly on the plant near their victim or on it. (Plate XXXVI.) *Rhogas Lefroyi* is a parasite of the spotted bollworms, *Earias insulana*, Boisd., and *Earias fabia*, Stoll, a very important check upon this common pest. *Microbracon leucaniæ* is parasitic upon *Nonagria uniformis*. Ddgn., the Wheat Stem Borer.

STEPHANIIDÆ.

Antennæ many-jointed.

A small family of less than one hundred species. of which one is known from India. *Wroughtonia carnuta*, Cam., was found in Bombay by R. C. Wroughton.

EVANIIDÆ.

The abdomen is petiolate, the petiole inserted on the dorsal portion of the median segment. Antennæ filiform, of thirteen joints, straight.

A small family of almost certain distinction from the position of the abdomen, only a very few insects outside the family sharing this character. Less than three hundred species are known in all, of which six occur in India.

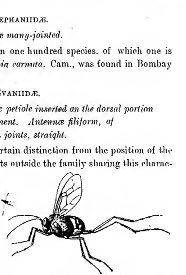

Fig. 96—EVANIA SP. × 2.

Evania is a genus of medium-sized insects, sombre in colour, with a very short abdomen, which is very slender at the base (peduncle) and broadly truncated at the apex. The sting is short, the wing comparatively small, the thorax robust.

To any one who has seen these active insects flying about, the genus will for ever be at once distinct. The imago enters houses and other buildings in search of cockroaches (*Blattidæ*) in whose egg capsules the female deposits her eggs and is one of the few flying insects one perceives on board ship. The larvæ destroy the eggs and one species has been very widely distributed over the globe where the household cockroaches are to be found. *Evania appendigaster*, L., is the European species found now in all but the coldest parts of all continents. *E. antennalis*, Westw., is described from Bombay and *E. albitarsis*, Cam., as well as *E. curvicarinata*, Cam., are Indian.

Gasteruption is a genus containing a large part of the species of the family and includes *G. orientale*, Cam., described from Bengal, and *G. mandibulare*, Cam., of whose habits apparently nothing is on record. It is likely to share the habits of the known species, and prove to be a parasite on *Aculeate Hymenoptera*.

Aulacus bituberculatus appears to be the sole other recorded species. Other species are known in Ceylon and it is probable that these with others will be found also in India.

TRIGONALIDÆ.

Abdomen ovate, five-jointed, not petiolate. Trochanters not fully divided. Both wings with a complex venation.

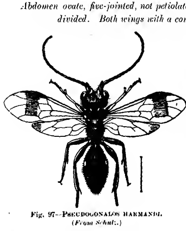

Fig. 97—PSEUDOGONALOS HARMANDI. (*From Schulz.*)

A small family of insects of which little is known. Schulz has recently listed the species (Genera Insectorum, 1907), one out of forty-two being doubtfully Indian. The known species are parasites on Vespidæ and hyper parasites on Diptera: no pupal cocoon is made. *Pseudogonalos Harmandi*, Sch. (fig. 97) occurs in Darjeeling, *Poecilogonalos pulchella*, Westd., in

Ceylon and Burma, *Ischnogonalos dubia*, Magr., in Burma and *Lycogaster rufiventris*, Magr., in Burma.

TUBULIFERA.

CHRYSIDÆ.—*Cuckoo Wasps.*

Trochanters one-jointed. Visible abdominal segments usually three.

This family is most easily recognised by the extremely hard, densely punctured integument and the bright metallic green or blue-green colouring. They are small insects, with rather small dusky wings. The head is of moderate size with large eyes and ocelli: the antennæ are short, consisting of a longer basal segment (*Scape*) and a number of short joints (*flagellum*). The thorax is large and well developed, the abdomen distinct, with usually three visible segments, the remainder concealed. The female has a long retractile ovipositor. The bodily structure is hard, designed to enable the insect to curl into a ball (fig. 99). So far as is known, all are parasitic upon Aculeate Hymenoptera and a number have been reared from different species. In the greater number

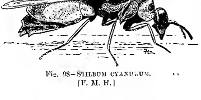

Fig. 98—STILBUM CYANURUM. [F. M. H.]

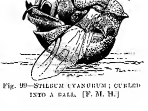

Fig. 99—STILBUM CYANURUM; CURLED INTO A BALL. [F. M. H.]

the host is not known and we are not aware that any Indian species has been carefully studied. The known hosts are tabulated here :—

Bembex sp.	parasitised by	*Hedychrum timidum*, Dohl.
Odynerus bipustulatus	,, ,,	*Hedychrum flammulatum*, Sm.
Megachile fraterna. ,, *monticola* *Eumenes petiolata* ,, *conica*	,, ,,	*Stilbum cyanurum*, Forst.
Eumenes conica ,, *petiolata* ,, *flavopicta*	,, ,,	*Chrysis fuscipennis*, Br. (see Jo. Bo. Nat. Hist. Soc. XII, p. 585).
Odynerus multipictus	,, ,,	*Chrysis angustata*, Mocs.
Sceliphron intrudens	,, ..	*Chrysis durga*, Bingh.
Eumenes dimidiatipennis	,, ,,	*Stilbum cyanurum*, Forst. (vide *S. splendidum*, Cretin, in Jo. Bo. Nat. Hist. Soc. XIV, p. 823).
Pelopæus, sp.	,, ,,	*Stilbum cyanurum*, Forst.
Eumenes conica	,, ..	*Chrysis orientalis*, Guer (Pusa).
Sceliphron coromandelicum ,, *madraspatanum*, F.	,, ... ,,	,, ,, ,, *Chrysis fuscipennis*, Br. (Pusa). *Hedychridium rugosum*, Sm. (Smith).
.. *bilineatum*, Sm.	.. ,,	*Chrysis* (?) *pubescens*, Sm. (Smith A. M. N. H. (2) IX, p. 45).

Bingham describes four sub-families :

Cleptinæ. Not known to be Indian.

Ellampinæ includes *Ellampus*, *Holopyga*, *Hedychridium*, *Hedychrum*.

Chrysidinæ includes *Chrysogona*, *Stilbum*, *Chrysis*, *Euchroeus*.

Parnopinæ includes *Parnopes*.

The identification of these genera and species can be found in the Fauna volume. *Hedychrum flammulatum*, Sm., is the only widespread species of its genus. *Stilbum cyanurum*, Forst., is said to be practically worldwide and is, in the plains, universal. The species of *Chrysis* are so far as known, mainly local but their superficial resemblance probably has led to the belief that they are all common and not worth observing or collecting. *C. fuscipennis*, Br., *C. fusca*, Fabr., *C. orientalis*, Guer., and *C. oculata*, Fabr., are widespread and common, likely to be found anywhere.

Collecting. Cuckoo-wasps are common in houses and in the open; they require to be caught with a net and may be killed with Cyanide or a B. C. bottle. Far more wanted than collecting is observation of their hosts and habits and rearing from nests of Aculeates. The part they play in the complicated relations of our insect fauna is not at present measurable and a far closer knowledge of them is required. They are common at nearly all times and as many infest the Aculeates that build in and around houses, are easy of observation. A really close study of one species would well repay the labour and time.

ACULEATA.

Our knowledge of this group is due largely to Wroughton, who worked in the Konkan, Rothney who worked for 14 years in Barrackpore and Bingham who worked for many years in Burma. The last has listed the species known up to 1896 in the Fauna of India, and there have been abundant papers since then adding new species. With the latter we are not concerned; Cameron has described hundreds of new species in a variety of publications. G. C. Nurse has added others and it will be long before all are described. Rothney's paper (Trans. Ent. Soc., London, 1903, p. 93) adds to our information and Horne's paper in Trans. Zool. Soc. VII, p. 168 (1870), must be consulted.

The most striking point about the Aculeates is the fact that the whole business of life is conducted by the imago; the larva is practically helpless and if not actually fed by the imago is at least provided with an ample supply of carefully gathered food which simply has to be devoured. Without careful search we never see the larva of an Aculeate and the imago alone is active. This specialisation in life history is associated with extraordinary specialisation in habits and consequently in structure; the activities of these insects excite the admiration of all who observe them and their extremely varied ingenuity is unparalleled in any other insect group; for this reason, they are placed at the head of insects in mental activity and intelligence and they are unquestionably very far removed from any of the primitive types of insect life.

At the same time it must not be thought that their activities show any mentality comparable to that of man; even ants are unreasoning and these insects are endowed with extremely complex and beautiful instincts, of so remarkable a kind that many naturalists see in these insects a powerful argument against the doctrine that such instincts, as all insect activities, are the result simply of natural selection and adaptation.

From man's point of view these instincts are in a sense admirable and are yet inferior since they are mere blind instincts which cannot vary and which involve no reasoning faculty. A dog has more reasoning power and a higher order of mentality than the highest insect; the absolute stupidity of the ant but the wonderful nature of its instincts is a curious contrast.

MUTILLIDÆ.—*Velvet Ants.*

Male. Pronotum reaching the tegulæ. A constriction between the first and second abdominal segments. Middle coxæ contiguous.
Female. Wingless, ant-like without abdominal nodes.

The wingless females are very readily recognised by their ant-like appearance and bright colours, there being no nodes on the abdomen as in *Formicidæ*. The males are usually recognisable as they have a characteristic appearance and colouring, but the above characters must be verified in case of doubt. The wingless females are small insects from an eighth to a quarter of an inch in length: the

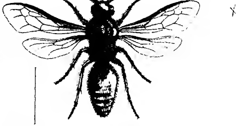

Fig. 100.—MUTILLA SEXMACULATA, MALE.

colours are always warning, striking and vivid, red and black predominating with white and golden spots or bands on the abdomen. The males are larger, up to half an inch in length, coloured in black and red, the wings usually smoky, the abdomen commonly red. The colouring is less conspicuous than that of the females and is perhaps a milder form of warning colouration.

The family practically consists of one genus, *Mutilla*. There is, however, the peculiar insect *Apterogyna mutilloides*, Sm., a species likely to puzzle any but a close student of this group. This insect has, in both sexes, a constriction between both the first and second, and the second and third segments; the winged male has a peculiar upturned spine at the apex of the abdomen and the venation of the wings is much reduced not extending to the outer margin. The insect is not common but is striking and deserves mention. It is one of the few insects found in the sandy wastes of some parts of North India and is also known from Barrackpore. Of Mutilla, some 120 species are described in the Fauna of India; as, however, the males of some species only are known, and the females of some, and as these could probably be paired off if we knew more, the number of species may be exaggerated. The discrimination of these species is by the colour markings, which are extremely constant, and the student should consult the key in the Fauna of India volume.

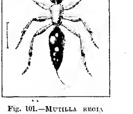

Fig. 101.—MUTILLA REGIA FEMALE.

Mutilla.—Is one of the insects far more common and well represented in the hot-plains than in the hills. The active females are to be found everywhere in moist as in very dry surroundings; the limited distribution assigned to so many species is due simply to the fact that in so few places have they been collected, though where they have been collected many species have been found. Anyone who observes closely the insect fauna of our fields is sure, sooner or later, to witness the mating of Mutillids. It varies in detail with the species; those seen by the author have been tolerably similar. The male is a powerful insect with long legs and strong wings; he finds the female, seizes her by the prothorax and flies off; on some convenient spot, he mates with her, clasping her firmly to him by his forelegs and standing erect on his others; she is perfectly helpless and is apparently firmly held throughout. The first time I was privileged to see this, I was much struck as in the frequent intervals the male shook the female with a twisting motion as we should shake a bottle whose contents we desired to mix well; this extraordinary performance is worth seeing, but occurs, so far as I know, not in all species, as in the majority I have seen the procedure was straightforward and not accompanied by this peculiar rite; unfortunately I was so interested that when I sought to capture them and determine the species they escaped.

It is impossible to discuss individual Mutillids in this place and the student will find full descriptions in the Fauna of India. The four commonest species are perhaps *M. dimidiata*, Lep. *M. interrupta*, Oliv. *M. analis*, Lep. and *M. sexmaculata*, Swed. but very little is known as to the geographical distribution in India of the majority of the species. All are parasitic upon Aculeate Hymenoptera, but few have been actually bred from their hosts.

M. regia, Sm. (fig. 101) was found in the nest of *Eumenes conica* and was also reared from the pupa of this wasp. G. C. Nurse also reared this species from the nests of *Eumenes esuriens* (Jo. Bom. Nat. Hist. Soc. XIV, p. 271). *Mutilla discreta*, Cam. has been reared from *Crabro orientalis*, Cam. in Pusa and *M. poonaensis*, Cam. from the nest of an *Eumenes* in the same place. (Plate XIII, figs. 1, 2.)

Collecting.—Mutillids are easy to collect, the females on the ground, the males in a net. The females should not be handled with the bare fingers as the sting is distinctly painful. Every mutillid seen "in cop" should be collected since this is the easiest way in which to match the sexes. A great deal of observation and rearing is required before we can estimate the importance of the group since their hosts are unknown and every opportunity of determining what their hosts are, should be taken.

SEX.

The *Mutillidæ* offer a striking example of that difference in structure connected with sex which is found in some form or another throughout the insect world. It is at first sight a striking thing to find that throughout a whole family, the female is wingless, but there are so many other striking differences that we may here draw the attention of the student to some salient points in this matter.

We may omit here all reference to structures such as ovaries, claspers, ovipositors, etc., connected with the primary needs of mating and egg-laying: these must obviously be present in every mature sexual form and on their examination must ultimately depend the determination of sex. Apart from these structures, which are not always readily discernible without dissection, there are a number of other differences less immediately connected with the actual sexual functions and which are often more readily discernible. We may at once notice the wingless females, so marked a feature in *Mutillidæ*. We are probably correct in saying that in this family the female has lost her wings since she does not require them in her search for the nests of her hosts but that the male retains them simply to aid him in his search for the female. The same is true of other forms, where the loss of wings appears to be an advantage but one which cannot be shared by the male as on him falls the work of seeking out his mate. Among Lepidoptera, the *Psychidæ* are an excellent example and a few *Lymantriidæ* exhibit the same phenomenon. All male *Coccidæ* are winged, all females wingless; many *Phasmidæ* have wingless females, while some of the species of the Reduviid genus *Physorhynchus* are winged only in the male, though some other species of the genus are wingless in both sexes, the wings however more completely absent in the female than in the male, as if the former had lost them first. In the Lampyride division of *Malacodermidæ*, wingless females are not uncommon and in some genera the females are practically unknown, only the males being found as winged beetles.

Uzel mentions the exact reverse of this in Thysanoptera, where we find a wingless species in which some females become winged to disseminate the species. This reminds one of the *Aphidæ*, where after a colony of wingless females is formed, winged females are found which fly away and start new colonies, though this last case is not connected with sex.

The next notable point in sex is size; here we have two groups, one in which the male is larger and the difference in size is connected with his functions; the other in which the female is larger apparently because on her falls the more arduous task of providing for the offspring or because the mere bulk of eggs to be produced and carried necessitates a larger body. Large males at once suggest the *Lucanidæ* (Stag beetles) and the *Dynastidæ*, the great size being connected with the hypertrophied mandibles or horns on the prothorax and head. Why these beetles should bear these large horns and have so massive a development is a question no one appears to have satisfactorily answered and we should like to see a careful inquiry made into the relative numbers of the sexes of these beetles either in one locality or in the offspring of definite parents. In these forms there is usually great variation in the actual amount of development of the horns or mandibles and in some species there are distinct types, known as *teleodont* (long mandibled) *priodont* (short mandibled) and *mesodont* (intermediate) in the one species. The large males of the *Mutillidæ* are accounted for (wrongly perhaps) when we consider that not only must they fly and be active, but that they usually seize and carry off the females and that further the eggs in this group are not bulky or abundant. Small males offer no apparent difficulty since it seems natural as we have said above. Marked difference occurs notably in *Phasmidæ*, in the social insects such as bees and termites, in many moths, some beetles, and in some *Acridiidæ*; it is probably correct to say that some preponderance in the female is the general rule in insects, but it is more marked for instance in *Atractomorpha* and some allied *Pyrgomorphides* than in most *Acridiidæ*, and the groups we mention will furnish conspicuous examples to the student. It is curious that this is less marked in Rhynchota and one is inclined to associate such sex differentiations with the more specialised and highly developed groups.

An interesting sex modification is that in which the female has more developed mouthparts than the male, as in the *Culicidæ* and blood-sucking *Chironomidæ*. In these forms the female alone can suck blood. It is possible that this really occurs more frequently than is recorded; there is, for instance, a marked difference in the size of the mouthparts of some Pyralids (*Lamoria*, etc.). Another and a fundamental difference that scarcely needs mention is the naturally longer life that the females enjoy: in a very great number of cases, the completion of the male's functions determines his death and this must precede the death of the female which has often to wait for a considerable time before she can successfully deposit her eggs. This is very marked for instance, in some species in which the female waits long periods as in the mango weevil (*Cryptorhynchus gravis F.*), where the males die in August, the females living until next March to lay eggs. We believe this occurs in a very large number of forms and it is a factor that must be taken into account in estimating the relative proportions of each sex found. It would be interesting to know, for instance, how far this occurs in long-lived imagines such as butterflies; do the males die early or do they wait until the females can lay eggs before mating?

We come then to a vast number of small modifications in one sex which are less directly connected with sex in the sense that they are connected only with courtship and the preliminaries to mating. The luminosity of some insects may be cited, the European glow-worm being an example of a female wingless beetle which is luminous possibly as a guide to the winged male. Our luminous beetles are so in both sexes and in the larvæ, so that this luminescence may not be connected with sex. A better example are the singing insects, in which the males sing, the females are silent. We have briefly discussed this elsewhere (under *Cicadidæ*) and it is not certain that song is really connected with sex, though it is likely to be so. In a great number of male moths and butterflies, scent production from special hair tufts is a feature of the males alone and the frequency with which this occurs points to its being an important factor in successful mating. The variety of situations in which these tufts occurs, their diverse form and size are marked features, for instance, in our Noctuidæ and Pyralidæ, while the male pouch and sexmarks of butterflies are simply scent producing organs.

Haase discusses this point (Zool, Anzeiger, XI. 1888, No. 287). Plateau remarks that in Lepidoptera, scent organs exist for three purposes; in *Danais* and *Euplœa*, they are defensive, the scent being unpleasant and derived from a caustic fluid; in some Lepidoptera, notably Bombycidæ and Saturniidæ, the scent is diffused by the female to attract the male, the latter having very sensitive organs of smell: in many butterflies the males emit a " seductive " scent, that has in some cases been compared to vanilla, and which is employed only in courtship. It is the last which Haase discusses; he states that scent organs occur in one of the following positions:

Wings.—On the whole upper surface of both wings. (*Pieridæ*). In tufts on the upper surface of both wings (some *Satyrides*). In a costal fold of the forewing (some *Hesperiidæ*). On the upper surface of the disc of the forewing (*Cynthia, Atella, Argynnis*, etc., and some *Hesperiidæ*). On the lower surface of the disc of the forewing (*Eurema*, etc.). On the folded costal edge of the hindwing (*Patula*). On the upper surface of the hindwing (*Pierids, Danais, Morphides, Satyrides*, etc.).

On the anal area of the hindwing above (*Papilionides. Ornithoptera, Pompeus*, etc.), or below (*Morphides*).

On the lower surface of the hindwing (*Plecoptera* in Noctuidæ). On the part of the two wings which rub together when in motion (*Catopsilia, Euplœa, Ergolis, Morphides, Mycalesis, Lycænides*, some *Hesperiides* and some Heterocera).

Thorax and abdomen.—Many Sphingids, Agaristids and some Noctuids have scent organs on the first abdominal segment. In some Pierids, in all Danaids, in Callidulids and some Noctuids, a tuft of odorous scales can be protruded from each side of the genital aperture.

Palpi and Legs.—In a Deltoid (*Bertula*) a tuft occurs on the palpi. in a few forms tufts occur on the tibiæ of all the legs, on the forelegs only (*Spodoptera*), on the middle tibiæ (many *Noctuidæ*), on the hind tibiæ (some *Hesperiidæ, Hepialidæ, Hyblæa* and many *Geometridæ*).

The student of *Pyralidæ* will find that he must study the male secondary sexual characters very carefully in distinguishing species and that they occur with great frequency in a very marked form. One of the commonest male characters, is a greater apparent development in the antennæ and this is shown in most moths, the female having often simple antennæ while the male has them ciliate, pectinate, fasciculate or modified in some way. Were more known of the actual habits of moths, we might be able to say whether these modifications gave the male a greater chance of finding the female, for instance, by giving the antenna a more delicate or special sense. At present nothing is known and there is no real information as to how insects find each other. This development of the antennæ is a feature also of *Culicidæ*, with a more astonishing difference in the relative development of the palps, those of the males being very much larger. There is also a surprising development of the antennæ in the male *Lampyridæ* in species in which the luminescence is little developed.

We cannot leave this subject without briefly touching the problem that every student finds of determining the sex of an insect. It is extremely irritating to find, for instance, characters given for the males only, while one has not enough of a species to have both sexes and one does not know, without dissection, what is the sex of the specimen one has. To deal adequately with this subject would require very many pages and a separate treatise. In some families sex-distinction is easy, as in *Locustidæ*, *Gryllidæ*, *Acridiidæ*, many Parasitic *Hymenoptera*, and those groups which have a distinct ovipositor. In others there is no such obvious distinction, and in some families dissection is actually necessary. This is the case, for instance, in the bulk of the *Rhynchota*, *Heteroptera*; Distant is discreetly silent in the Fauna of India on this point except where such obvious differences occur as in *Physorhynchus*. In some species, the possession of claspers points to the males (*Leptocorisa*), the larger bodies and distended abdomen of the female sometimes marks the female (*Dysdercus*, etc.). Coupling unfortunately affords no evidence as these forms couple in opposition. (Coupling is by opposition in *Lepidoptera* and *Hemiptera*, by superposition in *Coleoptera*, *Orthoptera*, *Diptera* and *Hymenoptera*). *Coleoptera* is another order in which there is no one characteristic of the male. There are abundant small characters in different families, but they must be learnt for each. In *Orthoptera*, the matter is simpler; in *Forficulidæ* the male has nine, the female seven abdominal segments; the genital styles mark the male Blattids; the male Mantids have two more visible ventral segments (eight, really nine), than the female (apparently six, really seven). The female *Phasmid* has the egglaying gutter or process; while the *Acridiid* female has two pairs of digging processes; *Locustid* and *Gryllid* females have usually an ovipositor. In *Rhopalocera*, the male sex marks are usually distinguishable in the form of glandular hair patches; in moths, Hampson has pointed out that the frenulum is simple in the male, compound in the female. In *Diptera* the antennæ of the male are plumose in some families, the eyes are larger and more closely approximated on the frons in others, and there are in some cases very distinct claspers. In *Neuroptera*, it is necessary to look for male claspers which, however, are not always present.

THYNNIDÆ.

Pronotum reaching the base of the wings, basal abdominal segment not constricted. Posterior legs short, female apterous.

A small family containing two Indian genera and six species, none common or generally to be found. The winged males have a distinct upturned spine at the apex of the abdomen (as does also *Apterogyna*); the recorded species are *Methoca bicolor*, Cam. (Barrackpore); *M. orientalis*, Sm. (N. India); *M. smithii*, Magr. (Bengal, Burma); *M. rugosa*, Cam. (Ceylon); *Iswara luteus*, Westw. (Sind); *Iswara fasciatus*, Sm. (Sind). Any observations on the habits of these insects will be of value as nothing appears to be known. (*Methoca* is by some authors (*e.g.*, André) classed with *Mutillidæ*).

SCOLIIDÆ.

Pronotum reaching the tegulæ. A constriction between first and second abdominal segments. Middle coxæ separated. Both sexes winged.

This family includes a number of moderate sized flying insects classed generally among wasps; none are very small, while some are amongst the largest of the Aculeates. The colours are usually warning to a greater or less degree, black with yellow or orange predominating. The head bears the antennæ, which are larger and more slender in the males; there are the usual three ocelli on the vertex; the mandibles are large; the thorax and body is robust, heavier in the female and usually clothed with rather thick hair. The legs are short and spinose, the wings well developed, the venation valuable for the discrimination of genera.

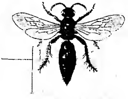

Fig. 102.—ELIS ANNULATA, FEMALE.

PLATE X.—FOSSORES.

Fig. 1. *Eumenes conica*, nest seen from the attached side, containing green caterpillars and a feeding larva.
,, 2. Nest as seen from outside.
,, 3. *Tachytes erythropoda.*
,, 4. *Astata agilis.*
,, 5. *Tachysphex testaceiceps.*
,, 6. *Larra sumatrana.*
,, 7. *Notogonia subtesselata.*
,, 8. *Lyroda formosa.*
,, 9. *Pison rugosum.*
,, 10 } *Trypoxylon canaliculatum.*
,, 11. }
,, 12. *Stizus prismaticus.*
,, 13. *Philanthus pulcherrimus.*

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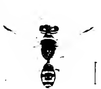
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Males are smaller, more slender and usually have spines at the apex of the abdomen.

Nothing appears to be on record as to the habits of this family in India ; as a whole they are probably parasitic upon the larvæ of Coleoptera in the soil, especially *Scarabæidæ;* they persistently fly over the soil, but none have been reared ; Froggatt (*Agri. Gazette*, N .S. Wales, 1902), records *Dielis formosa*, Guen., as an enemy of the beetle *Xylotrupes australicus*, Thoms., in Queensland ; the wasp burrows down to the grub in the soil, stings and paralyses it, lays an egg on it and goes away ; the larva on hatching devours the grub and pupates there. It is highly probable that our species have similar habits. The wasps visit flowers, not to obtain pollen but to feed on nectar.

Five genera and 87 species are recorded as Indian, of which nine are common in the plains.

Tiphia rufo-femorata, Sm., is a small black insect with red posterior femora, widespread but not very common. G. R. Dutt has ascertained that *Myzine dimidiata*, Guer. (known from male only), couples with *M. Madraspatana* Sm. (known from female only), and presumably they are one species.

Scolia includes large insects, thickly haired ; *S. quadripustulata*, Fabr. (Fig. 103), is the very common species, black with the abdomen usually red on the side and sometimes across the upper surface. *Elis* falls into two series, according as it has two or three cubital cells. In the former are the common species ; *E. annulata*, Fabr., is very common, the female black with white pubescence, the male with yellow bands across the abdomen ; the latter are commonly captured asleep in the evening or early morning, on grass stems or plants, and it is no uncommon thing to see a number settling down for the night on a convenient cane leaf. *Elis thoracica*, Fabr., is the large black wasp that frequents cotton flowers, and which is, perhaps, an important factor in cross-fertilisation. *Liacos analis*, Fabr., is also common, black with a variable amount of red on the abdomen.

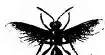


Fig. 103.—SCOLIA QUADRIPUSTULATA.

POMPILIDÆ (CEROPALIDÆ).

Pronotum reaching the insertion of the wings. Legs long.

The Pompilids are not a large family but contain some of the most conspicuous of the Aculeates. There are comparatively large forms, as well as very small ones. The colouring is sometimes distinctly warning, but not in all, the deep blue-black of *Pompilus analis*, for instance, not being of obvious utility. There are no striking structural features; the males are smaller, the abdomen with one more visible abdominal segment. The females have somewhat flattened forelegs in some cases, to fit them for burrowing and excavating in soil.

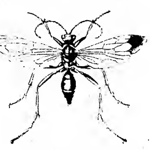


Fig. 104.—PSEUDAGENIA HONESTA.

The habits of some Indian species are known, but there is room for much observation. As a whole, these insects have the typical habits of *Fossores*, catching their prey, stinging it, laying it up in a convenient place for their young and depositing an egg there. Bingham states that "*Agenia, Pseudagenia, Paragenia* and, I suspect, *Macromeris* too, construct little earthen shells for nests." Others utilise available chinks or holes or make holes.

Macromeris violacea, Lepel., is a common insect, of whose habits practically nothing is known. Bingham records seeing a species carrying spiders, and G. R. Dutt has obtained clay cells (stored with spiders) under the bark of old trees, made of mixed mud and vegetable matter. *Pseudagenia blanda*, Guer., is a smaller metallic blue insect common throughout India.

G. R. Dutt has found that *Pseudagenia blanda* makes small earth cells under the bark of trees, the cells (filled with spiders), like those of *Sceliphron madraspatanum*, but smaller and always in pairs, the one cell smaller than another. From the larger cell the female emerges, from the smaller the (hitherto undescribed) male, the latter three days earlier than the former. It is apparent either that the mother wasp lays eggs of each sex alternately or that she can control the sex production, or that the greater amount of food stored in the one case makes a female imago.

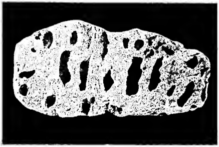


Fig. 105.—NEST OF SCELIPHRON COROMANDELICUM OCCUPIED BY PSEUDAGENIA CLYPEATA, × ½.

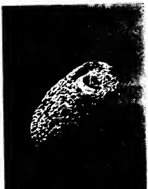


Fig. 106.—MACROMERIS VIOLACEA VAR IRIDIPENNIS; CELL, × 1½.

We figure a large compound clay nest from which were reared *P. clypeata*. The nest consists of an old nest of *Sceliphron coromandelicum*, of which the cells were occupied by the *Pseudagenia* ; since the latter requires a smaller cell, she divides the cells by a partition and then utilises them ; but she also builds on additional cells round the old ones ; in Fig. 105 the large cavities in the middle represent old *Sceliphron* cells. (the nest seen from below) the smaller holes round cells added by *Pseudagenia*. That the cells were originally made by *Sceliphron* is proved by the occurrence of a dead one in one cell. Hymenopterous and Dipterous parasites attack this *Pseudagenia*.

Salius includes a number of species, of which some are abundant. *Salius flavus*, Fabr., is the common yellow insect, the wings yellow with deep purple-black at the apex; it has been observed to store spiders in the ground. Bingham remarks that some store cockroaches or crickets in holes in trees.

The following notes record the observations of T. V. R. Aiyar, formerly Assistant at Pusa :—

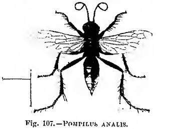


Fig. 107.—POMPILUS ANALIS.

From March to July this insect is the commonest of the bigger species of *Pompilidæ* in Pusa. It is found very generally in open meadows with a pretty hard soil and in such parts of the meadow where there are often found big holes made in the ground. Not uncommonly this insect is found under trees where the ground is covered by fallen leaves and twigs. In these localities it is found very busy searching holes for spiders; its active progression with its long limbs and occasional flight is very graceful to look at. With great patience it goes on visiting hole after hole. One has been watched searching every hole in half an acre in the meadow in the Botanical area for full two hours and a half with no success; at last finding the search fruitless, it flew away and perched on a distant tree.

When, however, the *Salius* is fortunate and in its search comes across an inhabited spider hole, it comes out of it quickly and prepares itself for the affray. The preparation consists of a slight rest followed by the cleaning of the antennæ with the front legs and of the abdomen with the hind limbs. It then carefully enters the hole and disturbs the tenant. Within a second out come both the wasp and the spider. The extreme care displayed by the wasp in dealing with its antagonist is worthy of remark. As soon as it comes out of the hole, it goes a little distance away from it and then turns round. The spider which is commonly a pretty big ground spider comes out of its home and stands at bay at the mouth of the hole. It does so with the ferocity of a wild beast, with its erect cephalothorax and jaws (with the poison fangs) wide open. It never moves away from the hole until it is overpowered, but simply turns round always facing the wasp. Its action is entirely defensive. There is seen a series of tactics and movements displayed by the wasp, which appears afraid of the death-dealing jaws of the arachnid and so approaches with great caution. It turns round and round and occasionally tries to jump on the spider. The spider continues defending and for about 5 minutes the fight goes on. The fossorian, however, knowing the weak point of the spider, *viz.*, its inability to strike upwards, waits for an opportunity to jump on the spider. At last by a clever and agile jump it alights on the spider and takes it unawares. The moment it is on the spider, it never waits for a second, but applies the sting and inoculates the poison, first paralysing the victim's poisonous weapons from below. Then again it stings, thrusting the lancet along the side of the cephalothoracic shield. The spider being thus paralysed, the fight ends. In some cases the spider proves more than a match for the *Salius*, in which case the latter, after trying its best, gives it up and flies away. After making sure that the captive is helpless, it leaves it behind and goes searching for a convenient hole. In one case the *Salius* was clever enough to appropriate the hole of its victim itself. In this case it first enters the hole alone and remains alone for some time underground most probably inspecting the hole. It then comes back and making sure that the spider is paralysed, takes hold of one of its cheliceræ with its mandibles and walks back with its face towards the captive to the hole. When, on the other hand, it does not like the spider's hole, it leaves the captive and goes away some distance and begins to search for a convenient nest. In one case the wasp has been seen to leave the captive, go straight to a particular hole, not approaching any other on the way, and then come back to the spot where the spider was. From this it appears that the wasp keeps a hole ready before it goes in search of a spider. While it is engaged thus, it often comes back to the spider to make sure that it is safe in the original spot. At this stage if the captive spider is taken some feet away from the original spot the *Salius* comes back and then after strolling all round, it finds the spider and in this case it stings it once again and then drags it some distance forwards and there leaving it, goes again in search of a hole. Several times it visits the paralysed spider to be sure of its safety. At last it drags the spider to a hole and then it does not come out for a very long time.

Salius flavus is never found frequenting houses as it almost exclusively confines itself to catching ground spiders.

Pompilus is the largest genus with some widespread species, of which, perhaps *P. analis* Fabr. (Fig. 107) is the most common. T. V. R. Aiyar made the following observations on this species. This red and black wasp is found very commonly haunting the trunks of big trees, especially species of *Ficus*, which generally contain numerous holes and chambers inhabited by spiders. I have now and then found individuals on the walls of old buildings and also some hunting ground spiders, but I have not till now come across any nesting on the ground. The following were my notes on the habits of a specimen of this species :—

1st June 1906.—As I was entering the lucerne field along the avenue close to the Waini road, containing clumps of bamboos, I heard a buzzing noise about me, and on turning round found a specimen of *P. analis* perch on the ground by my side and search holes. Watched the insect for about quarter of an hour. After some search it came across a hole very close to a small wooden post in the ground. It entered the hole and came back, followed by a big ground spider. Then ensued the usual fight. The combat was found to be exactly like that of *Salius flavus*, but with a display of greater fear on the part of the *Pompilus* and so additional care. After securing the captive, it disappeared for a few minutes and then came back to assure itself of the captive's safety as in *Salius*. This happened three times. On one occasion the spider moved a little when the *Pompilus* gave it a sting in addition to the ones administered during the combat. I found it impossible to follow it as it flew high up every time and disappeared, the black body and the transparent wings adding to the obscurity. In the end it took hold of the spider exactly like the *Salius* and began walking back. It directed its course across the avenue towards the bamboo clump on the side of the road. On reaching the clump of bamboos it began ascending one of these and then proceeded up for about 7 or 8 yards, when unfortunately it disappeared from my sight. I have very strong grounds for concluding that the wasp took the spider to a hollow in some bamboo, because although I have come across several individuals of this wasp dragging spiders, I have never found one taking a spider to a hole on the ground. It may be argued that the wasp dragged the captive up the bamboo and afterwards flew off with it, the burden being too heavy for conveyance to the nest without the vantage of an elevation to start from. But my having till now never seen any individual of this species nest on ground supports the former view.

The spiders which *P. analis* generally hunts on tree trunks and walls are web-spinning forms and compared to the ground spiders very small and powerless. In these cases the *Pompilus* finishes the fight very soon and at once drags the captive along the side of the tree trunk to an exposed hollow on the trunk; it leaves its victim then and searches for a hole in the tree itself. Meanwhile, I have tried removing the captive and placing it on the ground below; however, the wasp after some anxious search found it out and dragged it again up to the tree. This species also thus displays that power of finding out the paralysed spider if we remove the same and keep it away. When at last it finds a convenient hole in the tree to nest, it comes back and drags the captive home.

Aporus includes only three species, of which one, *A. cotesi*, Cam., may be found in the plains.

SPHEGIDÆ.

Pronotum transverse, not reaching the insertion of the wings.

This is a large family of Aculeata, with a great variety of forms. It includes large robust species with a length of an inch and-a-half and small slender insects not over a quarter of an inch long. The majority exhibit some form of warning colouration, bright yellow, metallic greens and blues, and similar bright tints predominating. The head is large, with ocelli and compound eyes, the trophi are well developed, not conspicuous, and the mandibles are robust. The thorax is massive, the abdomen often with a long petiole. The legs are of moderate length, the forelegs often modified for digging. Males and females are superficially alike, the latter having a well developed sting. As in all Aculeata, there is no free life history and none are social, the female storing food for the young. The larva is a white soft grub, without legs and with a small head. Pupation takes place in a silken cocoon.

Sphegids are the familiar digging wasps, whose prey consists of insects, stung to insure paralysis and laid up in this state in a suitable cell or burrow for the young to feed on. The process of stinging may be observed and is sometimes accompanied by other injury to the prey to insure its helplessness. So far as is known, the prey is, when laid in the cell, helpless, but not dead, and remains so until the grub attacks it; how far the permanence of this paralysis is due to the action of the wasp and how far it is induced also by the conditions in the cell is not known; a cricket stung by *Sphex lobatus* and laid up, presumably remains paralysed; but that cricket taken out and kept under other conditions may die if kept too dry or may to some extent recover under favourable conditions of temperature, moisture, air and light. There is no reason to doubt that paralysis is caused primarily by injuries inflicted by the wasp, usually in the form of a sting or several stings, which are directed against the nervous system and induce paralysis. The student will find accounts of some species below and further accounts in the literature mentioned. Horne described the habits of *Sceliphron* (Pelopœus) *madraspatanum* F. *S. bilineatus*, Sm., *S. violaceum* F. (P. bengalensis, Smith), *Trypoxylon rejector*, Sm., *Pison rufipes* Sm., and *P.* (Pisonitus) *rugosus*, Sm. There is a large field here for an observer gifted with patience and perseverance to add to our knowledge of the habits of these important insects. The actual economic importance of the group, so far as it can be gauged, is great since most of the species destroy insects of economic importance. It is, however, very difficult

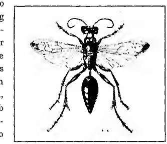


Fig. 103.—SPHEX LOBATUS.

to estimate this since their work is not at once obvious, and no estimates of number are easily obtained.

Sphegidæ are preyed upon by *Chrysidæ* and *Mutillidæ*, while the parasites of their prey indirectly check them because, in some cases certainly, when a *Sphegid* lays up a parasitised caterpillar, the parasite hatches and the Sphegid larva is deprived of its food. This is a curious fact and had we not observed it, we should hesitate to mention it. When we remember how large is the percentage of parasitised caterpillars very often, we may imagine that the Sphegid does often lay up parasitised caterpillars, which do not nourish their larvæ.

Astata agilis, Sm., though recorded from but few places, is probably widespread (Plate X, Fig. 4); it has been seen burrowing in sandy soil but its prey is unknown; it hunts usually among the decaying fallen leaves under trees.

Tachytes includes small and inconspicuous insects, nesting in soil and, according to Bingham, storing Orthoptera; *T. monetaria*, Sm., a black species with golden pubescence on the abdomen, is common, as is *T. erythropoda* Cam. (Plate X, Fig. 3).

Notogonia subtessellata, Sm., preys on crickets, storing them in burrows in the soil, or in the stems of plants (*e.g.*, in *Euphorbia neriifolia*) (Plate X, Fig. 7). This insect, which is the commonest of the genus in Pusa, is found very commonly in the vegetable garden and orchard, where the soil is fairly moist always. The reason apparently is that field crickets abound in these localities and the wasp is after them. The cricket generally hunted is a species of "Gryllodes" and very often not a full-grown one. In several cases the cricket escapes by its agile jumps, and it is only after allowing several crickets to escape that one is caught. The wasp paralyses the cricket by a sting (sometimes two) at the junction of the pro- and meso-sternum. It then drags the captive and leaving it in a prominent place, goes in search of a hole or to assure itself that its hole is ready to receive its prey. It soon returns and drags home the cricket. The process is different from that in a Pompilid. Here the wasp does not proceed backwards facing its captive, but instead poses itself almost above the captive and holding the antennæ by its mandibles proceeds forwards, both captor and captive facing one way. In this wasp there is distinctly a marked display of a high degree of instinct (intelligence?) in taking advantage of an elevation to start on the wing with its pretty heavy load. The wasp drags the cricket to the foot of the nearest shrub or plant and slowly ascends to about a foot from the ground, and from there it starts on its wings with the prey. It continues thus often on its way to its nest, which is generally a hole on the side of the hard bank. An interesting point in the habits of this wasp is that it digs into the soil to find its prey even when the cricket has a burrow opening to the surface. On one occasion, one was observed flying over sandy soil: she selected a spot and commenced to dig; when a little hole was made, she entered and came out carrying soil between her curved forelegs and her head, repeating this till there was a considerable heap of soil; this heap she then demolished by standing and kicking it away with her hind legs. While digging, a cricket came out from a hole by her, was eventually seen, pursued and captured.

Liris aurata.—This beautiful sand wasp is one of the most active among Sphegids. It is found in flower gardens and generally nests under thick bushes away from human observation. It is very often found haunting houses, especially store-rooms, in search of house crickets. The latter are notorious domestic pests attacking provisions, etc. This wasp, in frequenting dwellings, performs the part of an efficient natural check on these domestic pests. *Pison* includes small dark insects, of which *P. rugosum*, Sm., is common in the plains (Plate X, Fig. 9). Horne states that the nests of *P. rufipes*, Sm., are nearly globular, built in a group on a hanging creeper or tendril, and stocked with small spiders.

Trypoxylon (Plate X, Figs. 10-11) is common in houses, and I have seen *T. pileatum*, Sm., building in cane furniture in a verandah: they are extremely slender graceful insects, storing small spiders in their mud nests: nests are also found in thatch, and on one occasion a female was seen plugging her nest, which was in a hollow reed previously utilised by *Ceratina viridissima.* The hollow is not lined but is partitioned off into cells, each containing small spiders (Fig. 109). *T. intrudens*, Sm., builds in holes in walls and in crevices in books.

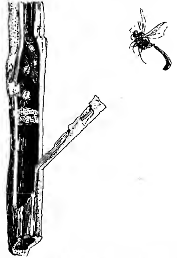


Fig. 109.—TRYPOXYLON PILEATUM BRINGING A SPIDER TO HER NEST IN A HOLLOW STEM; THE NEST HAS BEEN OPENED TO SHOW THE CELLS. [F. M. H.]

Ammophila is larger, with a long narrow abdomen and a rather Ichneumon-like appearance. Several are very common and their habits have been observed. The habits of *A. lævigata*, Sm. (Fig. 110), are briefly described in Indian Insect Pests (page 271), this insect burying *Plusia eriosoma* larvæ in soil. So far as is known, caterpillars and spiders are their prey and they do not make mud nests but burrow in soil. *A. atripes*, Sm., *A. basalis*, Sm., *A. lævigata*, Sm., and *A. erythrocephala*.

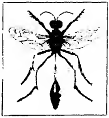


Fig. 110.—AMMOPHILA LÆVIGATA.

Fabr., are the commonest species, but the distribution of some species is local. The last is a large robust insect, very unlike the remainder.

Sceliphron includes the more robust mud-wasps so commonly seen in houses, which lay up spiders in earthen cells. *S. madraspatanum*

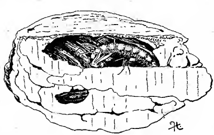


Fig. 111.—SCELIPHRON MADRASPATANUM; NEST REMOVED FROM A CORNER AND SEEN FROM BEHIND; IN ONE CELL A LARVA FEEDING; IN ANOTHER A SPIDER WAITING TO BE EATEN. [F. M. H.]

Fabr. (Fig. 113), is the commonest species; the female constructs mud nests, consisting of two to seven elongate cells, placed side by side; they are most beautifully constructed of mud and when unfinished are very striking objects (Fig. 112). But when the whole number are completed, stocked and closed, she puts mud over the whole in an apparently irregular manner but so as to give it the appearance of a rough lump of mud, when it is much less easily noticed. The nest is placed on a wall, a window-sill, on furniture or on tree trunks, and may be carefully concealed or in the open.

The cell is made, the first spider brought in and an egg laid on it near the base of the abdomen. The rest of the spiders are then brought; if the work cannot be completed before dark, a temporary mud cover is put on as the wasp does not sleep in the cell. When full, the cell is closed and a new one begun. The egg is white, soft, about 4 m.m. long. The larva on hatching feeds first on the abdomen of the spider it is on and then on its cephalothorax, proceeding afterwards to work upwards through the remaining paralysed spiders. (Fig. 111.) The larva is white, soft, leg-less, the segments indistinctly marked, the head very small: it becomes sordid-grey before maturity, when it measures about 14 m.m. Larval life occupies about 13 days, the full length being attained on the sixth day. There are apparently no moults during larval life, the extremely soft and unchitinised integument not preventing expansion as in harder insects. The full-grown larva ejects a mass of black excreta at the bottom of the cell and then spins a tough cocoon of very fine yellow silk which turns dark brown. It rests for three to six days and then moults, placing the exuvium at the bottom of the cocoon where it often adheres to the hind end of the pupa. The limbs of the future wasp are symmetrically folded under the body and are free, being easily seen. The pupa gradually assumes the imaginal colour and on the twelfth or thirteenth day the imago emerges; it cuts the cocoon and forces out the plug of mud that closes the cell, thus forming a circular orifice through which it can leave the cell. The total life from egg to imago is from 24 to 30 days, nest-making then occupies some time and there are probably five broods in one year in the plains. Hibernation takes place in the larval condition.

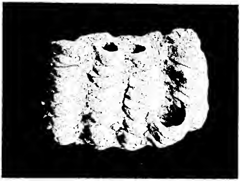


Fig. 112.—SCELIPHRON MADRASPATANUM—INCOMPLETE NEST.

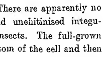


Fig. 113.—SCELIPHRON MADRASPATANUM.

This species, like others, is not allowed to work and increase unmolested but has enemies which prey upon it. *Chrysis fuscipennis*, Br., *Hedychrydium rugosum*, Sm., and an undescribed *Chrysis* are found in the cells; a Tachinid fly, of which as many as six maggots are found in one cell; a Bombyliid (*Hyperalonia sphynx*) is found in the pupal cocoon and in this case the pupa of the fly forces itself through the masonry so far as to allow of the emergence of the fly to the outside; finally, a *Mutilla* has been once reared from this species, unfortunately only a male.

This wasp is the subject of a curious belief in the Punjab; it has been noticed that it stores spiders and that eventually a wasp like itself is produced; not knowing what occurs in the cell, it is commonly believed that the wasp has the miraculous power of imparting its shape and colour to the spiders, and that each spider reappears in the new form.

G. R. Dutt, who has studied this wasp at Pusa, once removed the cells of a nearly completed nest which only required covering with mud; the wasp had made two cells, and had commenced bringing mud to plaster all over them when this was done; she however continued to bring mud and to plaster it over the marks left on the wall until she had produced the same appearance as she would have had the cells still been there, apparently unaware that the cells had been removed. The student should read the parallel cases described by Fabre, and translated in "Insect Life."

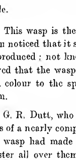


Fig. 114.—SCELIPHRON BILINEATUM CELL × 2.

Sceliphron coromandelicum, Lep., is a large species, of similar habits to the above. There are one to seven cells (rarely up to 12) in the nest, which is placed in buildings or on trees. It has similar parasites, and a Chalcid parasitises the Chrysid parasite, thus adding to the complicated fauna that centres round these nests.

S. bilineatum, Sm., is recorded from Western India, but occurs also in Behar. It constructs single cylindrical cells (Fig. 114) which it finishes by adding mud till the cell is smoothed over completely. The life history occupies about a month and this species is also extensively parasitised.

S. violaceum, F., is the common blue species which nests in houses, making no cell but taking advantage of natural holes, which it commonly closes with lime or plaster in preference to mud. It has been seen to utilise screw and nail holes in wood, bores in bamboos, the central hollow of a cotton reel, the tubular cavity of the handle of a cycle pump, and holes into which bolts were to fasten. It has also been found in the empty cells of *S. madraspatanum*, its larval cocoon being smaller than that of the latter. It is possibly the insect referred to in the following: Lahore Divisional orders :—The Ichneumon fly is particularly active at this time of the year, and the greatest care should be taken to prevent barrels of rifles becoming unserviceable from the rings of corrosion which invariably follow if the clay plug is not at once removed. The fly will build a complete nest within 24 hours, and every barrel should be looked through at least once daily to ensure its being free from this pest. (Statesman, 28th April, 1909.)

Sphex includes larger insects with a shorter petiole, best known from the very common green metallic species *S. lobatus* Fabr. (Fig. 108) which preys on the big cricket *Brachytrypes achatinus*, Stoll. Its habits have been described elsewhere (Journ. Bombay Nat. Hist. Soc., XV, p. 531); it has a curious habit of biting out a portion of the pronotum of its prey after it has paralysed it by stinging. It is seen actively at work from April to August: possibly the crickets are not sufficiently large before the end of April, necessitating a longer rest than that of other species.

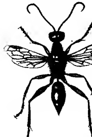


Fig. 115.—AMPULEX COMPRESSA.

Ampulex compressa, Fabr., is a very beautiful insect, common in the plains. In Pusa this insect is purely arboreal in its habitat. The chief haunts are the trunks of old Peepul (*Ficus religiosa*) and

Fig trees, which possess numerous holes and chinks. It is not an uncommon sight to see an *Ampulex* hurrying along the tree trunk searching hole after hole for cockroaches and occasionally flying to a distant branch only to return and continue the search in a few seconds. As far as observed, this species confines itself exclusively to species of *Periplaneta* for its prey. The specimen of *Periplaneta* is invariably bigger in size than the wasp itself. This wasp does not construct any nest, but generally makes use of some empty hole on the trunk of the tree, wherein it drags its captive. The manœuvres employed in capturing and paralysing the cockroach are almost the same as in Pompilids, but here there is not so much careful tact and dexterity displayed on the part of the wasp in dealing with the cockroach. The reason apparently is that the cockroach is not armed with any poisonous weapons ; it has to depend solely on its active motions and irritating spines for defence. Unlike the Pompilid and spider fight, the scene of the combat often changes, the cockroach taking to its wings very often. The fight is simply a pursuit of the desperately flying blattid on the part of the wasp and the moment it manages to alight on the back of the captive, the latter submits. The wasp loses no time in administering the sting. The sting is thrust along the side of the big prothorax and reaches the œsophageal ganglia. The cockroach does not, however, appear much the worse after the sting, and if the wasp after this so-called paralysing strays away in search of a hole, the cockroach manages to slip away slowly into some adjacent hiding place. This has been observed more than once.

One species of *Stigmus* has been observed by Dudgeon to store Aphides in holes in wood made by a boring beetle. (Jo. Bo. Nat. Hist. Soc. XV, p. 12.) *S. congruus*, Wlk., and *S. nigripes*, Motsch., have been observed collecting aphids in Behar. *Gorytes alipes*, Bingh., is not uncommon in Western India ; we have observed it burrowing in the damp soil of flower pots, the burrows nearly two inches deep, and stocked with the very common Fulgorid, *Dictyophara lineata*, Don. *Gorytes pictus*, Sm., has been observed to visit the rolled up sissoo leaves inhabited by the larva of *Apoderus blandus* (Curculionidæ), but the observer was unable to determine that the larva was carried off. It is possible that, since the weevil larva is in a case, this species paralyses it and lays an egg on it, thus not requiring a nest.

Stizus includes wasp-like insects whose habits are unknown; *S. rufescens*, Sm. (Plate X, Fig. 12), is common in the plains, and sometimes comes in numbers to dig in the ground in flat places near houses.

Philanthus pulcherrimus, Smith (Plate X, Fig. 13). This wasp is common at Pusa during the months of March and April. It is usually found on flowering plants, on the flowers of which bees are also hovering. This wasp attacks them, stings them and then flies with them to the nest. The bee is held by the wasp below the thorax between the legs. Nests of this wasp are in sandy banks, and are in the form of long narrow tunnels. Females were observed bringing bees (generally belonging to the genera *Halictus*, *Ceratina* and *Apis*) to their nests and the choice seems restricted to the family Apidæ.

Bembex sulphurescens, Dahlb., is another wasp-like insect, robust, coloured in yellow and black. *Bembex* makes burrows, which it is believed to keep open, feeding the young daily with fresh Diptera; this is an interesting habit, and it may be hoped that the habits of the Indian species will be observed. This species is usually found flying over the soft sand by rivers, etc.

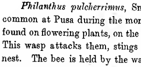


Fig. 116.—Bembex sulphurescens.

Cerceris is stated to be predaceous upon beetles principally *Chrysomelidæ*, in India; they are small wasp-like insects; *C. pictiventris*, Dahlb., *C. instabilis*, Smith, and *C. flavopicta*, Sm., are the most common. *Oxybelus* is smaller with several species, none known to be widely spread. *O. squamosus*, Sm., has been observed by Purushottam Patel to collect the biting fly *Stomoxys calcitrans* and also the common housefly (*Musca* sp.), and carry them off to provision its nest which is in the form of an oblique tunnel in sandy soil.

Crabro buddha, Cam., is a small black and yellow species, which has been reared from pupæ in a tree. *C. bellula*, Cam., has been seen nesting in wet soil in a garden in Western India. *C. orientalis*, Cam., is similar, and has been reared from pupæ found in tunnels in a dry mango branch. The dry wood was bored through extremely thoroughly and contained large numbers of cells packed with Diptera : a Mutillid (*Mutilla discreta*, Cam.), was reared from one of the cells. Bingham remarks that he saw a *Crabro* carrying off Aphides. as do the European species and this is likely to be the habit of some of the above species. Nurse records rearing *C. balucha*, Nrse., from hollow reed stems in which it had stored "houseflies." (Jo. Bo. Nat. Hist. Soc. XV, p. 16.) *C. ardens*, Cam., was observed in Pusa to have stored its nest with small flies and two species of *Crabro* were observed carrying off aphides from a Capsicum plant in a house.

EUMENIDÆ.

Wings folded longitudinally, middle tibiæ with one spine at the apex, the claws dentate.

These wasps include the small slender *Odyneri* measuring as little as a third of an inch in length and the large robust *Eumenes* which occasionally measure over an inch. The colouring is commonly warning and the females have a formidable sting. In some the petiole is well marked and long, in others it is less noticeable. The antennæ are of moderate length. with 12 joints in the male, 13 joints in the female. The pronotum reaches the base of the wings; the legs are of moderate length and slender. All are winged in both sexes and the females are

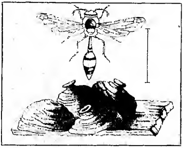


Fig. 117. EUMENES ESURIENS WITH ONE FINISHED AND THREE INCOMPLETE CELLS (SIC).
(*From Horne.*)

commonly seen engaged in making or provisioning the cells for their young.

The life history of no Indian species has been really studied in great detail though the habits of some of the species are known. These insects have the habits of the typical stinging predators, paralysing insects with their sting and laying them up for their young to feed on. Our Indian species are solitary and make cells, not nests. They are beneficial in that they destroy caterpillars, but their influence is probably not very great as their numbers are not very large.

Bingham enumerates nine genera as Indian, of which all but three will be found in the plains. *Eumenes* is the important genus, containing the well-known "potters," which prepare mud cells in houses and store these with caterpillars. R. C. Wroughton describes rearing 11 cells, of which three yielded parasitic beetles (*Mordellidæ*), three *Chrysidæ*, two flies and only three were unparasitized and produced *Eumenes*.

An account of the habits of Indo-Malayan *Eumenidæ* by Mons. Maindron will be found in Ann. Soc. Ent. Fr. 1882, pp. 69, 169, 267 and 1885, 219: the latter refers to *E. petiolata* only. Horne also has notes on the habits of Eumenids. The readers should see the account of *Eumenes dimidiatipennis*, Sss., by Lt.-Col. Cretin (in Journ. Bombay Nat. Hist. Soc. XIV, p. 820), which is a model of what such observations should be.

Some are extremely common in houses and are a serious nuisance owing to the spots chosen for nest building. *E. petiolata*, Fabr., *E. dimidiatipennis*, Sss., *E. esuriens*, Fabr., and *E. conica*, Fabr., are common and may be looked for everywhere. *Eumenes conica*, Fabr., makes its mud cells on walls, window frames, cement floors, etc., in houses. A single nest consists of seven to ten cells, each of which is round in plan, semi elliptica

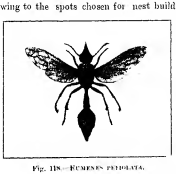


Fig. 118.—EUMENES PETIOLATA.

in section. In making a cell, the wasp brings a pellet of mud and spreads it out in a curve; she brings more and more, working it all up into a wall rising from the base she builds on, and curving inwards till there is a small round aperture left; she then puts on a neat rim (Fig. 117) and the cell has just the appearance of the upper half of an ordinary Indian gylah (water-jar). Through the opening she slips paralysed caterpillars, usually green semiloopers (Plate X, Figs. 1, 2); if they are large, three to five is enough; if not, as many as eight are put in. The egg is laid before the caterpillars are put in and hangs by a thread from the roof of the cell; when the cell is stocked the rim is demolished and the cell closed; another is then begun above and when the full number are made, the whole is finished off with mud evenly. The wasp is very sensitive to disturbance and readily abandons the cells; if the cell is more than half stocked, the transformation still takes place though the wasp is of a much smaller size. When a cell is partly demolished and left undisturbed, the wasp will often repair the damage and in this respect she shows a much less fixity of instinct than does *Sceliphron* for instance. The complete making, storing and closing of a cell usually occupies one day.

The egg is a delicate white object, about 4 m.m. long and hanging by a stalk about 1·5 m.m. long. On hatching the larva puts out its head but does not leave the egg shell so long as it can feed from it; it attacks the nearest caterpillar and only when it has grown a little does it leave the egg shell completely. When it has eaten all the caterpillars it spins a delicate cocoon, pupates and emerges. The imago then cuts through the cell and escapes. *Chrysis orientalis*, Guer., *Stilbum cyanurum*, Forst., *Chrysis fuscipennis*, Br., and a Tachinid parasitise this species, and in one case every cell of a nest of ten contained a Chrysid. *Eumenes edwardsii* has been reared from a clay cell, oval with rounded ends, found on a blade of grass.

Rhynchium has similar habits, collecting caterpillars, and is found everywhere: the common species are *R. hæmorrhoidale*, Fabr., *R. brunneum*, Fabr., *R. abdominale*, Illig., and *R. nitidulum*, Fabr. The last makes a cluster of up to 25 oval cells coated with black gummy material in which are stored her prey. *R. brunneum*, F., stores her nest with the caterpillars of the Pyralid, *Marasmia trapezalis*, Guer. Chalcid parasites attack these species. (Fig. 119.)

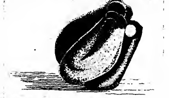


Fig. 119.—RHYNCHIUM NITIDULUM NEST.

Odynerus is believed to store caterpillars in holes or in small mud nests. Most are small insects, black and yellow in colour, without a petiole. A number of species are recorded, few of which are known to be widespread.

O. punctum, Fabr., and *O. ovalis*, Sss., are likely to be found anywhere in the plains. *O. punctum* has been observed by T. V. R. Aiyar to utilise the holes bored in chairs to fix the cane in, when the cane is broken and the hole empty; this hole she fills with small caterpillars, after which she closes it with mud. The same observer noted the latter carrying off the larva of the Groundnut Leaf Miner (*Anacampsis nerteria*, Meyr) to store in her nest.

VESPIDÆ.—*Wasps.*

Wings longitudinally folded in repose. Middle tibiæ with two terminal spurs; claws simple.

These are small to large insects, with warning colouration of an evident kind. The petiole is usually long and slender, the legs of moderate size, the pronotal angles reaching the insertion of the wings. The fore tibia bears a cleaning comb through which the antennæ is drawn, as is also the case in *Formicidæ*. The females have one more joint (13) in the antennæ than the males and one less abdominal segment (6) but are otherwise similar. In the majority of the species, social habits are observed; the nest may last more than one season, but in our common species this is not usually the case though

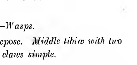


Fig. 120.—ICARIA FERRUGINEA.

successive communities may continue nests in the same spot. Workers, *i.e.*, imperfect females, are found in the more highly organised communities and a nest may contain a large number of individuals. Owing to the ferocity of their disposition and the virulence of their stings, precise observations have not been made into the habits of these insects in India and little is known of them.

Nests are commonly made of papery material consisting of chewed vegetable fibre. *Polistes hebræus* may often be seen working at dry posts or trunks from which the bark has been stripped, first moistening a spot, then working off the fibre and taking it away. A nest consists of cells of hexagonal form, hanging with the opening downwards; in the simple nests of *Icaria* there are two rows of cells only; in the more complex nests of *Polistes*, the cells form horizontal combs, hung by stalks, and with a diameter of six or more inches in rare cases: there may be one comb below another but the combs are open all round. In *Vespa*, there is an envelope, the nest completely enclosed and with the combs inside clear of the envelope so that there is access to each comb all round; in others the comb is attached to the envelope and access is gained by a central space passing up through the combs.

Fig. 121.—NEST OF ICARIA ARTIFEX.

The wasps feed on caterpillars, mantids, bugs, grasshoppers, beetles and other insects and some constantly seek for fruit juice, sugar, sweets and such material. The young are fed up on the crushed insects brought home by the parent or worker, but few details have been recorded. The number of caterpillars these wasps eat is apparently very large indeed and large nests probably exercise a considerable influence in keeping caterpillars down. The females hibernate in shelter in the colder parts of India for about two months or longer and it is at this time they are found in houses. Wasps have a distinct economic value as predaceous insects but are in some cases not welcome neighbours. The "hornets" which attack persons in India are species of *Vespa* whose nest has been disturbed and their stings have been known to cause death.

Of this family, 7 genera and nearly fifty species are recorded as Indian. Bingham figures the nests of two species of *Ischnogaster*, one solitary, one social, and regards this genus as the link between the solitary Eumenids and the social Vespids (Journ. Bombay Nat. His. Soc. V, p. 244).

Icaria ferruginea, Fabr. (Fig. 120), is one of the common species in the plains; it is the red-brown wasp with the yellow band across the second abdominal segment found commonly in Bombay and the Central Provinces. The hanging nest consists of a small number of delicate elongate cells. (Fig. 121.) *Polistes hebræus*, Fabr., is the common insect making hanging nests in the verandahs of houses and in similar sheltered spots. This species has been to some extent observed: the fertilised females hide away in cracks and chinks in verandahs, roofs, trees, etc., in November; we have seen numbers of them flying about seeking a refuge and they fight freely when two are trying the same spot. Here they remain all the cold weather, emerging as the warm weather commences in March. In 1907 they emerged as early as the third week of February, as did other hibernating Aculeates. The female then builds the nest, lays eggs in it and rears the young till they emerge to help her: larger nests are then made and these may last until later in the year or new nests may be begun by single females at any time. This insect has been reported from Peshawar as being so abundant in the Field Telegraph Stores that these could not be removed and as rendering houses uninhabitable in the Deccan by nesting in the verandahs. The nests are the habitat of a Pyralid larva (*Hypsopygia Mauritialis*, Guen.) which feeds on the larvae (see below).

Polistes stigma, Fabr., is the only other common species of this genus and it has been observed to nest in trees. Next to the yellow wasp (*P. hebræus*) this is the commonest of the genus in Pusa and the only other species often come across. We have found this insect attaching its slender paper nest made up of five or six hexagonal cells to the branches of trees overhanging the river.

Vespa includes the large wasps common in towns at sweetmeats and wherever sweet stuff is to be obtained. *Vespa cincta*, Fabr., and *V. orientalis*, F., are the common plains species; the very large *V. magnifica*, Sm., and *V. ducalis*, Sm., are notable hill species. *Vespa cincta*, Fabr., is not as common as *V. orientalis*, F. It is found generally in thick forest. It makes its nest in the holes of big fig and other forest trees and has been observed to attack the nests of *Polistes hebræus* and carry off the larvæ from the cells, the *Polistes* making no opposition.

Vespa orientalis, F., has also been observed hiding away for the winter in holes in buildings. Bingham states that the nests are in trees or at the foot of a tree or attached to the beams of a house. Their stings are, as he remarks, very painful and to be avoided if possible. There are many obscure points about this insect and we would like to see it properly investigated. It is the commonest of the species in India and is fond of selecting old buildings and walls to construct its combs (Plate XI) when many individuals are employed in the work. These nests are sometimes very large and extend far into loose masonry in old buildings, the communities being very populous. They are, in the colder parts of the plains, abandoned yearly, the fertilised females hiding away till the cold passes and then starting again; in this way the same nest may be tenanted year after year. In sweetmeat stalls in bazaars this is a pest, perching on the exposed sweet stuffs in numbers, but it is curious to find that it injures no one, though driven away now and then.

COLLETIDÆ.

Tongue emarginate at apex, short and broad.

This is a small family of somewhat rare insects which are not social. They are of small size, all black in colour and inconspicuous. Two genera and ten species are known from India and of these none can be regarded as common or widespread in the plains. *Prosopis mixta*, Sm., is perhaps the most common and will probably be found more widely.

Nine species are included in this genus and a single *Colletes* (*C. dudgeonii*, Bingh.) has been found in Sikkim.

APIDÆ.—*Bees.*

Tongue acute, not emarginate. The thorax with branched hairs, the basal tarsal joint dilated.

It is not always easy to recognise a bee at a glance and a fair knowledge of other Aculeates enables one, by elimination, to place doubtful forms. Actually the group is not well defined structurally though it is so on a combined appreciation of habits and structure. Bees are of small to moderately large size, their colours often dull, often more or less warning. The head is well developed, usually with three ocelli; the antennæ are of moderate length with a scape and a flagellum; the mouthparts are of varied form but include a pair of cutting mandibles, a lower lip and maxillæ which form the tongue, often very long, and two pairs of palpi; there is great variety in these mouthparts and they are of value in the classification. Bees utilise their trophi in a great variety of ways which are really very little understood but they are essentially modified biting mouthparts of great complexity with the lower lip functioning as a lapping organ for imbibing liquid. The thorax forms a compact mass and is highly chitinised; the abdomen is oval, the petiole short and not noticeable. The ventral surface bears the *scopa* or pollen-collecting brush in those species which collect pollen in this way. The legs are short, hairy and the hind tibia and basal joint of the tarsus are dilated and densely pubescent for carrying pollen. The use to which most aculeates put the hairs is for cleaning antennæ and other parts; pollen-collecting hairs may be modified cleaning hairs.

The *Apidæ* include social and solitary species, the social instinct being well developed in *Apis* in particular though perhaps to a less degree than in some Termites and ants. The majority have essentially the same habits and life history; the females collect nectar and pollen of flowers to feed themselves, to feed their young or to store up for the benefit of their young. A minority are parasitic, laying their eggs in the nests of their more energetic food-storing brethren.

In the simpler cases, as in *Megachile*, each bee makes a solitary nest, preparing one cell at a time, filling it with a paste of honey and pollen, and laying an egg in it: we then find species which live in a common burrow with separate cells, (*Halictus*) or which prepare a number of cells in one place and have a "nest" which suffices for one or more complete broods (*Xylocopa, Anthophora*); finally we find the higher social forms in which a nest contains not only sexual individuals but imperfect winged females which carry on the nest, the reproduction being limited to a small number of individuals, and the multiplication of nests taking place in the highest forms by the joint efforts of workers and sexual individuals. *Xylocopa* is an instance, but in this genus the community lives for one year only, the impregnated queens living over the winter: the honey bees are the highest social forms, with however only three classes of individuals, males (drones), females (queens) and imperfect females (workers); in these forms the nests are more permanent, and continue for an unknown period in some cases, or if the actual comb is deserted, the community goes on. In all cases the larva is helpless and must either be fed or be provided beforehand with a supply of food, either for its own use or that of its host if it be a "parasite." There is thus no free life history and the activities of these insects are confined to the adults.

With nearly thirty genera and a large number of species it is impossible to mention more than those species which are likely to be found generally in the plains. The student must consult Bingham's Fauna of India for descriptions of species.

Halictus is a small bee with many hill species, and a few plains ones which nest in wet soil. The presence of an anal rima in the female distinguishes them. *H. senescens*, Sm., is a common plains form.

Nomia is the next genus (we omit *Sphecodes* and *Andrena*) containing common insects: *N. elliotii*, Sm., and *N. oxybeloides*, Sm., are black with silvery white pubescence; the known species nest in earth, carrying pollen on their hind legs to stock the cells. The nests of *N. westwoodi* are found in damp soil in flower boxes and gardens, about four inches below the surface. *Lithurgus atratus*, Sm., is the bee that visits cotton flowers so persistently; the habits of *L. dentipes*, Sm., are described by Horne (Trans. Zool. Soc., VII, p. 175).

PLATE XII.—MEGACHILE ANTHRACINA.

THE BLACK LEAF-CUTTING BEE.

Fig. 1. Part of a series of leaf-cells taken from a hollow branch.

,, 2. A single cell opened to show the larva feeding on the pollen-mass.

,, 3. Full-grown larva.

,, 4. Cocoon, after the leaf covering is stripped off.

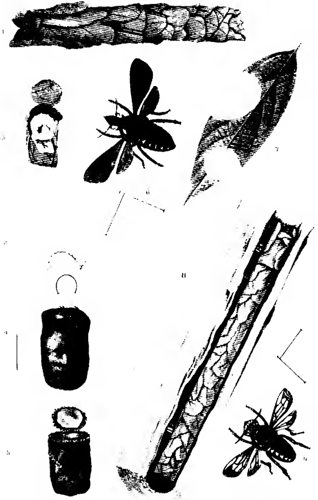
,, 5. Cocoon, after emergence of the bee.

,, 6. Imago, female.

,, 7. Leaf of Pigeon pea (*Cajanus indicus*) from which an oval side-piece (above) and a round end-piece for the cell have been cut.

,, 8. Complete series of eight cells in a tunnel in a branch; two of last year's cocoons, without leaf covering, are shown beside.

,, 9. Imago, male.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Megachile includes the very familiar bee that builds mud cells in our houses in any tubular cavity that offers itself. The work of the leaf-cutting species is well known, though we doubt if many people have seen these insects at work. *M. anthracina*, Sm., is the common leaf-cutting bee of the plains, which cuts neat pieces out of the stiff leaves of rose, *Bauhinia* and pigeon pea. These it takes away to line its cells, which it fills with pollen paste. We figure the cells of these species found in a tree. (Plate XII.) A point of interest in this species is that it is found as an imago only after the rains, *i.e.*, October and November. In captivity the larvæ rested from December to September in the cell. This is the case in Behar, but it may not be true of all India. *M. disjuncta*, Fabr., is also common and makes mud cells filled with paste. It has the base of the abdomen covered with whitish pubescence. The commonest species is *M. lanata*, Fabr., with base of the abdomen red-brown; this builds the mud cells (Fig. 122) in houses and also, as does *M. disjuncta*, in soil. In the former case, a mud cell is made, in the latter case, a casing of leaves is applied to the sides of the burrow direct. It is common both in the dry hot weather and after the rains. *M. conjuncta*, Sm., makes its leaf cells in a hollow bamboo. *Megachile lanata* is attacked by mites, which fix themselves to the larval integument and draw in fluid so that their abdomen becomes immensely dilated after the manner of the 'honeypot' ants (*Myrmecocystus*).

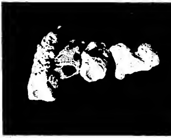

Fig. 122.—CELLS OF MEGACHILE LANATA, × 1.

Parevaspis is a parasitic bee found in the nests of *Megachile*; *Parevaspis carbonaria*, Sm., is the common Indian species. *Ceratina viridissima*, D. T., is the delightful little metallic green bee that tunnels in dry stems and lays up food there; it is common throughout India. (Plate XIII, Fig. 4.) The pupa is not in a cocoon but simply lies free in the cell separated by a wall of fibre from its neighbours. (Fig. 123.) The egg of *Ceratina* (like that of some other insects) increases in size after it is laid, from about 2 m.m. to over 3·5 m.m. in length; a chalcid parasitises the larvæ, four having been found in one cell as pupæ. The larval period is from 9 to 13 days, the pupal from 13 to 18 days in October, November. G. R. Dutt has found a cell in a hollow twig in thatch containing two larvæ, the cell sealed with black wax, which he reared to *Heriades parvula*, Bingh. This little bee is comparatively rare but occurs in Behar as well as in Burmah.

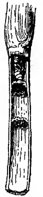

Fig. 123.—CERATINA VIRIDISSIMA PUPA IN CELL AND EMPTY CELL. [F. M. H.]

Coelioxys includes the black bees with rather sharply tapering abdomen that one sees hovering around walls and buildings. *C. basalis*, Sm., is said by Bingham to be parasitic upon *Megachile lanata*. *C. decipiens*, Spin., is the second common species.

Crocisa is said to be parasitic upon *Anthophora* and there is a resemblance in build and colour between them; of the former, *C. histrio*, Fabr., and *C. ramosa*, Lep., which are conspicuously black and white are common; *Anthophora* nests in the soil; *A. zonata*, Linn., and *A. violacea*, Lepel, are likely to be found. (Plate XIII, Figs. 5, 6.)

Xylocopa includes the familiar large carpenter bees which make tunnels in hard dry wood; they are large, usually black insects, with dark wings and are distinctly the largest of the bees in the plains. *X. æstuans*, Linn., in which the male is covered in yellow pubescence, the female in black, is the very common species, whose nests may be seen in posts and beams. (Plate XIII, Figs. 7, 8.) *X. fenestrata*, Fabr., *X. amethystina*, Fabr., and *X. iridipennis*, Lepr., are also common. *Xylocopa* *tenuiscapa*, Westw., in Ceylon is, according to Green (Ent. Mo. Mag., 1902, 232), the host of the Cantharid, *Cissites Debyi*, Fairm. He also figures there the cavity in the base of the abdomen in which lives the Acarid parasite *Greenia Parkinsi* Oudem.

Bombus, the "Bumble-bee" of Europe, is entirely a hill species and the beautiful Bombi one sees in the hills do not descend below 3,000 feet. (Plate XIII, Fig. 9.)

The species of *Apis* are the common honeybees, three species occurring in India wild. These are readily distinguished, so far as the workers go, by their size. *A. dorsata*, Fabr., being the largest, *A. indica*, Fabr., the medium sized and *A. florea*, Fabr., the smallest. While all three are common in India, they do not all appear to occur together; *A. dorsata* is the big bee that builds large nests in the forest and away from cultivation; *A. indica* is common generally in trees, as is *A. florea*, which in the plains of India is very often found making its single combs in any convenient position on a building. Bingham mentions *A. indica* as the commonest bee of Burmah, but *florea* is at least as common in India and its nests are far more often seen.

A great deal can be written about these bees and the reader is advised to consult Horne's article in Trans. Zool. Soc., 1879, VII, p. 181, as well as Hooper's Agricultural Ledger on bees-wax. An English abstract of Castets' article on bees of South India (Revue des Questions Scientifiques, Brussels, October, 1893) will be found in the Tropical Agriculturist, January, 1908, p. 48. It is of interest as containing an account of the wild bees, as also of *Melipona* (Trigona) *iridipennis*, Smith. For practical directions in bee-keeping in India Douglas' Handbook of Bee-keeping in India (1884) should be consulted.

Bees collect pollen from flowers, as well as nectar, and some collect a resinous matter from buds, from bark and other parts of plants. On the two former they feed themselves or their young; with the latter they make the nest tight. Wax is a secretion produced by young bees and used to make cells for honey and comb. About 16 to 20 pounds of honey is said to be eaten by young bees to yield one pound of wax.

Melipona is distinguished by having one cubital cell in the forewing only; it includes the small bees which build nests in trees and cracks of buildings; they are often called Dammar bees from the dark resinous matter they use in making their nests. *M. vidua*, Lep., is apparently the only Indian species at all common and the genus is probably found almost wholly in forest localities. Horne has remarks upon the habits of *M. smithii*. Bingh., (*Trigona ruficornis*, Sm.), which he found at Benares.

INSECTS AND FLOWERS IN INDIA.

I. H. BURKILL.

The Xylocopas are the most important of flower-visiting insects in the plains of India, and are of very general distribution. They have large size and long tongues, and they visit persistently all day, and some of them also on moon-lit nights. The Sunn hemp crop is largely fertilised by them, and possibly the Indian pulses. Cassias in Calcutta are commonly visited by one of them and many large showy flowers.

The place of *Xylocopa* in the plains is, in the hills, taken by *Bombus*, whose methods of work, degree of persistence, etc., are more or less completely known from studies in Europe. *Bombus* ascends to the snows visiting Aconites, balsams, the small honeysuckles, etc., which grow high up.

The genus *Anthophora* has species both in the region of *Xylocopa* and the lower part of the region of *Bombus*; one of its species, *A. zonata*, does great service to plants in the plains, being a diligent visitor often to flowers a little less showy than *Xylocopa* seeks, such as the Labiate weeds of India, and to flowers into which it creeps such as *Costus speciosus* or *Ruelia*.

Of Apis the three Indian species are important. They all seem to have the persistence of the hive bee, keeping generally to the same species of plants at one spell of work, and they are all diligent; but they cannot work so fast as larger insects. Whereas *Xylocopa latipes* was observed to visit 30 jute flowers per minute and *Xylocopa æstuans* to visit 35 jute flowers per minute, *Apis florea* visited about 10—15 flowers per minute (see Journ. Asiatic Soc. Bengal, 1906, pp. 516 and 518). The rate at which *Apis florea* works on the extra-floral nectaries of cotton is about 16 fruits per minute. The short tongue of *Apis florea* sends it to comparatively insignificant flowers. It is common in places on *Corchorus* (jute), *Evolvulus* and other flowers about as broad as the insect is long. In the drier hills *Apis indica* is a very important flower-fertilising insect, especially where, as behind Simla, it is domesticated.

The effect of the water-logging of Eastern Bengal on the flower-visiting insect fauna might be very interesting to study; Xylocopas nesting in trees, Apis dorsata, Apis florea, etc., persist; but the ground nesting species cannot.

PLATE XIII.—MUTILLIDÆ AND APIDÆ.

Fig. 1. Mutilla poonaensis, cocoon.
„ 2. „ „ female.
„ 3. Steganomus nodicornis.
„ 4. Ceratina viridissima.
„ 5. Crocisa ramosa.
„ 6. Anthophora cingulata.
„ 7. Xylocopa æstuans, female.
„ 8. „ „ male.
„ 9. Bombus tunicatus.

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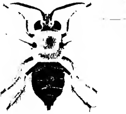
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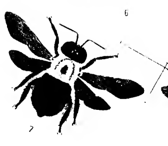
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The habits of the flower-visiting shorter tongued bees are for India quite unstudied. *Halictus* is common enough in some places and *H. senescens* is recorded from Behar as having some connection with the pollination there of cotton. It is worthy of passing remark that in Europe some of these short-tongued bees have been found to have the very closest inter-relations with particular species of plants. For instance. Bryonia is visited by a Halictus and by little else, and the *Halictus hardly visits* anything else, but the Bryonia flowers. The tongue of *Prosopis* is very short indeed.

Among the wasps, we find both long and short-tongued species ; *Odynerus* for instance is long-tongued, *Vespa* short-tongued. *Vespa* seems to be not unimportant in the pollination of Chiretta (*Swertia Chirata*) in Sikkim. The long-legged, slow-moving *Polistes* of the plains go to exposed honey. Sphegids, Pompilids and Scoliids may be seen in India at exposed honey.

Of Lepidoptera there are many common plains species which doubtless do a considerable amount of flower pollination, *e.g.*, *Danais*, *Terias*, etc. They seem to require a good deal of liquid during the day but often much of it is merely water taken from a wet mud bank. The least inconsistent in habits are perhaps the Sphingids, which are not uncommonly to be seen flower visiting both by day and by night. Possibly some *Hesperiids* are also in a measure not inconsistent in their flower visiting.

Diptera in the plains seem to play but a small part in flower pollination. It is different in the Himalayas where large Bombyliids join the Bombi in going to rather specialised flowers, and where out of the *Syrphidæ*, *Rhingia* and *Eristalis* are not uncommon. Tachinids also have some importance in the hills, but perhaps not in the plains. It is to be assumed that our large evil-smelling Araceæ attract muscids, but so far no thorough investigations have been made. A little beetle crawls into a foul-smelling *Typhonium ?* which grows in Lower Bengal.

Bibionids are often common on flowers in the hills and Anthomyids not frequent both in the hills and the plains.

Of the relations of other insects to flowers there is really nothing to remark : and it may be added here that there is an uninvestigated field in the study in India of flower pollination by birds. Birds at times visit for honey, and at times for small insects lying hid within the flowers. Keeble's account of his observations on bird-pollination of *Loranthaceæ* in Ceylon (Trans Linn. Soc. Bot. V. pp. 91-96), and a few remarks by Lieutenant-Colonel D. D. Cunningham in his "Indian Friends and Acquaintances," p. 130, comprise all that has been put on record. (The student should also consult Mr. I. H. Burkill's papers in the Journal of the Asiatic Society of Bengal, 1905 onwards.)

FORMICIDÆ.—*Ants.*

The basal one or two segments of the abdomen are in the form of detached nodes.

Ants are sufficiently familiar but the above character is occasionally required to verify the fact of a specimen really belonging to this family. They are in general small insects, of dull colouring, usually brown or black; in only a few is the length greater than a quarter of an inch and these large forms will be taken for wasps. The head bears antennæ which have a long basal joint (scape) and a number of short joints (flagellum); in the males of some species the scape is short. The mouthparts are small, the mandibles often of peculiar form. The thorax is much modified in different species and in different forms of the same species. The legs are long and most species can run actively. The abdomen is distinct, in the female and worker of six visible segments, in the male of seven, and is usually larger in the female.

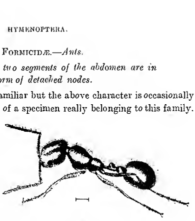


Fig. 124.—SOLENOS ISPGEMINATA, WORKER.

Ants are social, living in communities in which there is a considerable amount of specialisation of forms to serve the purposes of a useful

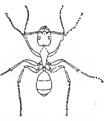


Fig. 125.—CAMPONOTUS COMPRESSUS, WORKER MINOR, × 3.

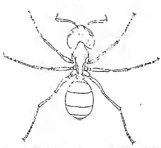


Fig. 126—CAMPONOTUS COMPRESSUS, WORKER MAJOR, × 3.

division of labour; the nest commonly consists of males and females, with various forms of workers: the degree to which this specialisation goes, varies very much with the species. Commonly there are two or three forms of workers, the soldier with large head and mandibles, the worker, major and minor, with more normal structure. A nest may consist of a greater or smaller aggregation of individuals and there are a few species which share the light-shunning habits of Termites, most nesting in soil, trees, etc., but working in the light.

In habits there is the greatest diversity; we cannot discuss this subject in this place nor have we much that is original to add to the little that is known. The reader should consult the following papers:—Jerdon (A. M. M. H. (2), XIII, pp. 45, 100); Wroughton (Jo. Bo. Nat. Hist. Soc., VII, pp. 39, 179); Rothney (Trans. Ent. Soc. London, 1889, p. 355); (Jo. Bo. Nat. Hist. Soc., V, p. 38); Rothney (Trans. Ent. Soc. London, 1895, p. 211); Aitken (Jo. Bo. Nat. Hist. Soc., IV, p. 151: V. p. 422); Green (Proc. Ent. Soc., London, 1896); Green (Jo. Bo. Nat. Hist. Soc., XIII, p. 181).

In general, the ants are scavengers, the workers bringing to the nest the food for the whole community. This food consists of dead insects,

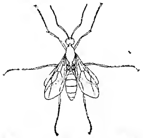


Fig. 127.—CAMPONOTUS COMPRESSUS, MALE, × 3.

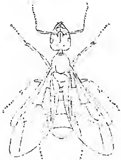


Fig. 128.—CAMPONOTUS COMPRESSUS, FEMALE, × 3.

any available nutritious animal matter, the sap of plants, any nutritious vegetable matter that can be obtained; in this sense ants are excellent scavengers and as they are practically everywhere in the open, they serve an extremely useful function. In some species this habit is specialised in one direction ; some are "harvesters," storing in their nests seeds of grasses and small millets, occasionally even that of rice. *Holcomyrmex*, *Messor*, *Phidologiton* and *Phidole* are the best known harvesting ants and these live entirely in this one manner. In others the "agricultural" habit takes another form and what correspond to our "cows" are kept and milked ; the latter are insects which suck the sap of plants and yield a sweet excretion which the ants remove ; Mealy bugs (*Coccidæ*), Green Fly (*Aphidæ*), *Psyllidæ*, *Membracidæ* are the important groups of "cows." while the larvæ of many Lycanids are attended by ants and yield excretion. *Camponotus*, *Cremastogaster*, *Cataulacus* and *Œcophylla* have this habit as part of their activities and the care they take of their cattle is in some cases very marked : it is no uncommon thing to see a shelter built over a colony of mealy bug, and in South India *Lecanium formicarii* is found only under hard shelters erected by ants on trees. Other ants are predaceous and carnivorous, going out on foraging expeditions to seek live food, such as insects. Though termites live retired, they are attacked violently by some kinds of ants (*Lobopelta*). Rothney states that in Madras, two ants (*Monomorium salomonis*, Linn., and *Solenopsis geminata*, Fabr.) are deliberately introduced into warehouses to check the depredations of white ants. This practice is not uncommon in Northern India and the Natives of India are familiar with the kind of ant which should be brought in. The *Ponerinæ* and *Dorylinæ* include hunting ants, though one species of *Dorylus* has also the termites' habit of attacking plants underground.

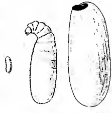


Fig. 129.—POLYRHACHIS SIMPLEX EGG, NYMPH, PUPAL COCOON, × 5.

The life-history is known in a general way but not in detail : the eggs are laid by the female and tended by the workers in the nest ; the larva is a white helpless grub without legs, which is fed by the workers and is itself incapable of exertion. These larvæ and pupæ are found in galleries in the nests, and one may often see the nest being moved, the little white larvæ and pupæ being carried by the workers. In some, the pupa is free, in others in a silken cocoon which the larva itself prepares.

An interesting feature of ants, especially of the fiercer and more war-like species, is the fact that they are mimicked by other insects extremely closely. *Sima rufonigra* is mimicked by a Sphegid *Rhinopsis ruficornis*, Cam., in Barrackpore and by *Rhinopsis constanceæ*, Cam., in the Konkan. It is also commonly mimicked by a spider, as is *Sima nigra*. Wroughton records the mimicry of a species of *Polyrhachis* by the nymph of a Coreid bug *Dulichius inflatus*, Kby. (Proc. Ent. Soc., Lond. 1891, p. XVII).

Bingham lists the Indian species in Vol. II of the Fauna of India. Hymenoptera, based on Forel's papers (Jo. Bo. Nat. Hist. Soc., VII, etc.). In this volume 498 species are enumerated as Indian, of which those mentioned below are common in the plains with a fairly wide distribution.

Dorylinæ.—Male large and wasp-like; workers blind, subterranean. Female apterous, blind and like a queen termite. Pupa in a cocoon. Worker with a sting.

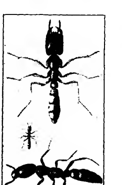


Fig. 130.—DORYLUS ORIENTALIS WORKERS.

There are two common genera, *Dorylus* with one-jointed pedicel. *Ænictus* with two-jointed pedicel in the workers. *Dorylus* makes its nest below ground and behaves much like a termite. *D. orientalis*

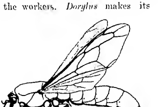


Fig. 131. DORYLUS LABIATUS. MALE, × 1½.

Westw., attacks plants, eating them below or at the level of the soil. The workers have been observed to attack the workers of *Pheidole indica* and carry them off to their nest, where they were killed and cut into pieces. The males come to light and they are common towards the end of the cold weather in late February. *Ænictus* is a hunting ant. (Jo. Bo. Nat. Hist. Soc., VII, p. 177.)

Ponerinæ.—A constriction between the two basal abdominal segments; sting powerful, exserted.

Lobopelta is said to make a sound; it feeds on termites. Rothney remarks of *L. diminuta*, Sm., that it marches in two long lines in files of two. *Diacamma vagans*, Sm., was found to be common at Barrackpore by Rothney, nesting under stones or brick-work; the sting is said to be "pungent." G. R. Dutt has observed it nesting in soft soil at the base of a big tree in Pusa: outside the nest were several heads of workers of *Camponotus compressus*.

Myrmicinæ.—The pedicel two-jointed in all the forms. Pupæ not in cocoons.

Myrmicaria nests at the foot of trees with a kind of embankment round it. *Cremastogaster* is a tree ant, making globular nests of papery

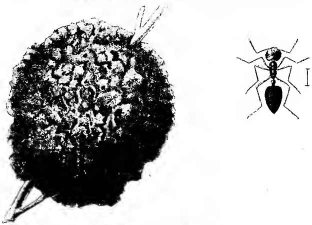


Fig. 132.—CREMASTOGASTER DOHRNI; NEST AND WORKER. [I.M.N.]

material, or nesting in hollows in trunks or branches; nests were found in Mantid egg cases, the eggs having been partly removed. It has a habit of turning up its abdomen over the body as if threatening to use its sting. It bites freely and is stated to keep "ant cattle." *Monomorium destructor*, Jerd., and *M. pharaonis*, Linn., like some later species, are widespread over the tropics and have probably been carried by shipping. *M. indicum*, Forel, is not uncommon in buildings in the rains, nesting in cracks in the masonry. *M. gracillimum*, Sm., is found in houses in thatched huts and on trees. A nest was found in the excavated pith of a dry stalk of Sann Hemp in the wall of a thatched hut; they have a very painful sting and are a decided nuisance in houses. They attend mealy bugs on plants and also carry off flour, fat, etc., from store rooms. *Holcomyrmex scabriceps*, Mayr., is the familiar harvesting ant of the Punjab, which gathers seeds of grass and millets into its nests and stores them in galleries. The nest is easy to find as there is a ring of chaff round it at a little distance and the ant's roads can be followed to the nest from some distance. Comparatively large quantities of seed can be extracted from a nest and, in times of scarcity, this grain is dug out of the nest and used as food. We have seen a pint of seed taken out of one nest.

Solenopsis geminata, Fabr., is the brown ant of India, nesting usually in the ground. *Phidole rhombinoda*, Mayr., is stated by Rothney to surround its nest with the leaflet of a mimosa, as a protection against the sun. *Sima rufo-nigra*, Jerd., is very common in India, nesting in trees. The sting of the female is, according to Rothney, "the most painful of any Aculeate I am acquainted with." This virulent insect appears in May. Nests have been found also in hollows in bamboos with neat round exit holes at intervals. *Sima alloborans*, Web., nests in young shoots of bamboos and in tree trunks: when disturbed, the ants discharge a drop of white liquid.

Cataulacus includes sluggish ants of a jet black colour: *C. taprobana*, Sm., nests in hollow bamboos and *C. latus*, For., in the branches of teak and siris trees.

Dolichoderinæ.—*Tapinoma melanocephalum*, Fabr., has once been found to be injurious under peculiar circumstances. The workers were found in large numbers in small temporary chambers at the base of young tur plants (Cajanus indicus) grown for inoculation with wilt in a special plot; these plants they ate into just below the soil level, eating right into the stem and through to the bark till the plant fell over, cut completely off; as much as half an inch of stem would be completely eaten and the object apparently was, not the removal of the plant but the actual soft stem for food. Plants that had been inoculated were most attacked, and it is possible that the tissues were specially attractive on that account. As a rule, this ant feeds on anything sweet and visits Aphides and Coccids constantly. The nests are underground, very deep and populous.

Iridomyrmex anceps, Rog., nests in sandy soil near plants infested with aphids, and there are regular tracks to these plants; the nests are deep and several minor ones are often connected to a larger central one, the workers freely entering all. The eggs and larvæ were found abundantly in February at a depth of one inch, sparingly in July at a depth of nearly a foot. The workers emit an unpleasant odour; they visit aphids, coccids, membracids, etc., the glands of *Cassia orientalis*, and also carry off dead insects.

Camponotinæ.—Pedicel with one joint. No definite sting, the poison being ejected from the orifice at the apex of the abdomen. *Oecophylla smaragdina* is the familiar red tree ant of India, which makes large nests in trees, often enclosing mealy bugs in a covering of webbed leaves. The green females are found yearly in June starting fresh nests on plants, and these nests can be easily observed from the commencement. The workers are very active and fierce, collecting all manner of dead insects and even living ones if these are inactive; caterpillars are attacked, cut up and carried off to the nest in pieces. A colony will have many small depots on one tree, each consisting of a number of leaves webbed together and containing a colony of

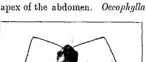


Fig. 133.—OECOPHYLLA SMARAGDINA WORKER.

Coccids or a store of dead dry insects. If one is opened and patiently watched, it will be seen that the workers draw the leaves together by their mandibles and legs, while others, from inside, web them together with silk produced from a larva held in the jaws. This is a really extraordinary sight and may be seen at any time.

Acantholepis frauenfeldi, Mayr., var *bipartita* nest in soil at the foot of trees, or in hollows in masonry. They visit Aphids and Coccids, and also collect dead insects. *Prenolepis longicornis*, Latr., is widespread in the tropics; the nests are under fallen leaves or in decaying tree trunks and contain *Paussidæ*.

Polyrhachis simplex, Mayr.—Nests of this species are found on low bushes, high trees, under bamboo sheaths, and on sugar-cane leaves.

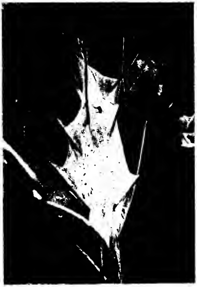


Fig. 134. Webbing of Oecophylla smaragdina on Pipal shoot enclosing Lecanium hesperidum.

The nest is always constructed in such a way as cannot be easily discovered by a casual eye. A greater portion of it is covered over by leaves and the portion open to view is not easily recognisable. It looks from a distance as if it were made of clay and cowdung, mixed with dry pieces of leaves, straw and grass. In reality it is a brown silky cobwebby material, over which are thickly and closely laid dry pieces of leaves, straw, etc. Just as *Oecophylla smaragdina*, F., workers make use of salivary threads secreted by their larvæ in folding the edges of leaves together, so do the workers of this species. They catch hold of the larvæ between the mandibles and carry them over to the places where the web is required to be spread. The larvæ go on laying and stretching threads mechanically, as wanted. Other workers bring dry pieces of straw and spread them over the web while it is still fresh. When a nest is cut open from any part, a few of the workers at once rush up to the spot and plant themselves as sentinels to guard the breach, while others remove larvæ and pupæ or whatever there be in that portion of the nest, to a secure place. After the chamber opened to view is cleared of what it contained, the workers hold the torn portions between their mandibles and pull inwards. Thus the aperture is made as narrow as possible, and then a couple of larvæ are brought and the web is drawn across the rent in the usual way. The whole inside of the nest is lined with the brown silky cobwebby material, and the partitions between different chambers are also made of this material, but without straw, etc.

Ants of this species also tend cattle for whose protection they prepare byres of the same cobwebby material and covered also in a similar manner as their nest. Such byres were found on a sugar-cane leaf, and also on a weed, close to established nests of this species. Workers were seen going in and coming out of those cattle sheds. On removing the covering large clusters of sugar-cane, aphis were found in the former and *Monophlebus* in the latter shed. Workers of this species have also been observed carrying a large dead fly to their nest. Pupæ are encased in light brown cocoons. The winged sexes were obtained from nests in August and September.

Myrmecocystus setipes, Forel, nests in the ground in open places, and there is often a heap of soil thrown outside the nest. The workers collect dead insects and millipedes, and nests have been found stored with the wings and bodies of winged termites which they collect in great quantity; the worker-majors carry the worker-minors when on the march.

Camponotus compressus, Fabr., is the familiar black ant of India, the large worker-majors coming into houses. Nests are usually in the soil at the foot of a tree but occasionally in a wall. They visit Aphides, Membracids and Coccids and also feed freely upon termites if a nest or gallery is exposed. The winged sexual individuals fly at dusk on warm still evenings in the rains and are frequently to be seen at light.

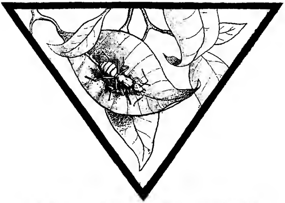


Fig. 135.—OECOPHYLLA SMARAGDINA; QUEEN WATCHING OVER LARVÆ, WHEN COMMENCING TO FOUND A NEW NEST.

COLEOPTERA.—(Beetles).

The first pair of wings (elytra) thickened, accurately adapted to the body and completely covering the lower wings, which fold longitudinally and transversely in repose. Many species are wingless, and in many the elytra are abbreviated, not covering the abdomen. Mouthparts of the predaceous or herbivorous biting type. Antennæ of varied forms never setaceous, usually eleven-jointed. Simple eyes usually absent. The integument is hard; the parts accurately co-adapted to form a rigid outer skeleton.

Metamorphosis complex; the larva a grub with complete or reduced legs, without suckerfeet and without tubercles bearing hairs. Silk is not utilised in the formation of the cocoon, but anal secretion takes its place; after emergence from the cocoon the imago usually passes through a resting period during which the integument hardens.

The order includes minute to large insects, of varied habits, including herbivores, predators, scavengers, both aquatic and terrestrial, with no social and scarcely any parasitic forms.

No order is so easy to recognise as this, and only in rare cases, where the elytra are much reduced or are soldered together, will a beetle appear different. Looking at a beetle from above, the antennæ, the large prothorax, the scutellum, the elytra and the pygidium (plate over the anus) are seen, except where the last is covered by the elytra. The large wings are folded below the elytra. Looking from below, the antennæ can be seen, inserted below the head, the large mandibles and the labium, with usually two pairs of palpi; the legs, with the coxa embedded in the sternum, the trochanter, femur, tibia, tarsus. The antennæ assume different forms as shown in figure 137; in 1, the basal joint is elongate and forms a scape, the apical three joints form a club and the remainder form a funicle, the whole antenna being elbowed (*Rhynchophora*); in 2, the antenna is simple, filiform (*Phytophaga*); in 3, it is moniliform, each segment a little expanded (*Cantharidæ*); in 4, it is serrate on one side (*Sternoxi*); in 5, it is clubbed, the three apical segments expanded on both sides (*Clavicornia*); in 6, it is filiform (*Adephaga*); in 7, it is clubbed, the club formed of leaflets closely folded together (*Melolonthidæ*); in 8, it is irregularly clubbed (*Hydrophilidæ*); in 9, it is incompletely clubbed, with the leaflets not forming a compact mass (*Lucanidæ*).

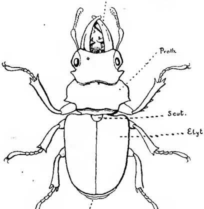


Fig. 135.—LUCANID BEETLE, MALE, DORSAL VIEW. MD., MANDIBLE; PROTH., PROTHORAX; SCUT., SCUTELLUM; ELYT., ELYTRON; PYG., PYGIDIUM.

The tarsi are composed of five joints in some forms, of four or three in others; in one division (*Heteromera*) the tarsi of the first two pairs of legs are five-jointed, of the third pair, four-jointed. In the *Phytophaga* the tarsi appear to be four-jointed, the tiny fourth joint being invisible at the base of the fifth.

There are characteristic features in the immature stages which mark the group as a whole. Eggs are of two types, the soft oval eggs laid in concealment, the harder variously-shaped eggs laid openly. The latter are not ornamented as are those of the *Lepidoptera*, are not of the form characteristic of Hemiptera with lids, nor of the typical Dipterous cigar-shaped form. The larvæ are without suckerfeet, and if free-living, frequently have the single anal tube, which functions as a suckerfoot, as well as two dorsal cerci or processes. The hairs or hair-tufts on tubercles arranged as in *Lepidoptera* are not found in this order, and larvæ, if hairy, have long tufts not arranged in series. No larval form can be confused with the Coleopterous larvæ which live free lives, the characters of Neuropterous, Hymenopterous, Lepidopterous or Dipterous larvæ being wholly different.

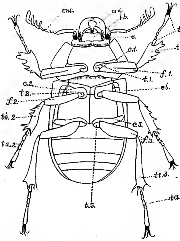


Fig. 136.—LUCANID BEETLE; FEMALE, FROM BELOW. ANT., ANTENNA; MD., MANDIBLE: LB., LABIUM: E., EYE; C. 1., C. 2., C. 3., COXÆ OF LEGS; T., TROCHANTER: F., FEMUR, TI., TIBIA; TA., TARSUS.

There are a few prominent points about Coleopterous larvæ that we may notice here. The tarsi are two-clawed in the *Adephaga* only (excepting *Haliplidæ* from these). Anal cerci occur only in *Haliplidæ*, *Hydrophilidæ*, *Silphidæ*, *Scaphidiidæ*, *Staphylinidæ*, *Histeridæ* and *Elateridæ* in part, as well as in the *Adephaga*. If we except the above, the larvæ of all have legs except *Bruchidæ*, part of *Cerambycidæ* and *Buprestidæ*. Omitting all the above, the Scarabæoid (white, curved, wrinkled) grub occurs only in *Scarabæidæ*, *Melolonthidæ*, *Lucanidæ*, *Passalidæ*, *Ptinidæ*, *Bostrichidæ* and part of *Chrysomelidæ* (*e.g. Clythrinæ*). In the *Dermestidæ*, the body is clothed in long fine barbed setæ, usually aggregated behind into tufts. All aquatic larvæ coming into none of the above divisions are either *Dascillidæ*, *Parnidæ*, *Haliplidæ* or *Chrysomelidæ* (part). In a number of families not included above, the apex of the abdomen is provided with prominent chitinised processes and the apical segment is harder than the others. These include *Rhipiceridæ*, *Trogositidæ*, *Colydiidæ*, *Mycetophagidæ*, *Melyrinæ*, *Cleridæ*, *Melandryidæ*, *Pyrochroidæ*, *Mordellidæ*, *Tenebrionidæ* (part), *Cioidæ*, *Lagriidæ* and *Elateridæ* (part). The remainder exhibit none of the above general characters. More detailed characters for each family are given below, but these are based less on Indian species than on European or American larvæ. The number of larvæ of Indian beetles actually known is very small.

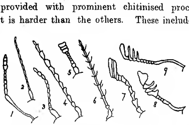


Fig. 137.—ANTENNÆ, 1 CURCULIONID, 2 CHRYSOMELID, 3 CANTHARID, 4 ELATERID, 5 EPILACHNID, 6 CICINDELID, 7 MELOLONTHID, 8 HYDROPHILID, 9 LUCANID.

Pupation takes place openly (the pupa fixed at the tail), or in a cocoon of mud, of anal excretion or of fibres, never of fine woven silk. The peculiar resting stage of the newly emerged imago, while not universal, is general enough in forms whose pupæ are hidden as to be worth noting.

Classification.—The beetles are divided into series upon characters based upon the antennæ and tarsus as follows :—

Lamellicornia.—Tarsi five-jointed ; antennæ with apical joints expanded in leaf-like form and forming a club which can be opened and closed (figure 137, 7, 9). Four families.

Adephaga.—Tarsi five-jointed. Antennæ simple. Nine families.

Polymorpha.—Tarsi variable ; antennæ usually clubbed or serrate. **57 families.**

Heteromera.—Anterior tarsi with five, hind tarsi with four joints. 15 families.

Phytophaga.—Tarsi with apparently four joints, densely pubescent. 3 families.

Rhynchophora.—Tarsi as in Phytophaga, head more or less prolonged into a rostrum. 4 families.

In actual practice, it is, as a rule, easy to place a beetle in one of these series. The peculiar antennæ marks the *Lamellicornia* instantly. The tarsi and simple antennæ distinguish the *Adephaga*. *Heteromera* are distinct by the tarsi; as *Phytophaga* and *Rhynchophora* have the same tarsi in most cases, the beginner will confuse some forms; but the simple antennæ of the *Phytophaga*, and the usually clubbed and elbowed antennæ, as well as the usually evident rostrum, of the *Rhynchophora*, clearly mark all the common species of each series likely to be met with. All other beetles, especially if with serrate or clavate antennæ, are *Polymorpha*, a series that includes the old Serricorn and Clavicorn groups, and in fact is an assemblage of all that are not clearly of one of the five distinct series.

The classification of the species that fall into each series is by no means simple and no agreement will be reached until more is known of tropical forms. Especially is it difficult to fix the families and the student will find very diverse views expressed in various books. We treat Melolonthidæ as a single family; there is little reason why it should not be regarded as consisting of several families. *Chrysomelidæ* are another large assemblage that could justly be regarded as at least 11 and more probably 15 families, as is done by some authors. We have preferred to retain these as sub-families, but the student will have no difficulty in finding the equivalents of any families he may see discussed by writers.

When a particular specimen has been placed in its series, there may be more or less difficulty in deciding on its family. There should be no difficulty in the Lamellicorn, Adephagous, Phytophagous, or Rhynchophorous series, provided the characters mentioned are compared. For the other series, no keys or sufficient characters can be given. Excepting the few larger families, very little is known of the smaller families, and while it is possible to give characters based on European or American species, these distinctions may not always apply to new and undescribed

Indian species, which alone the student is likely to find. We enumerate the diagnostic characters of the families known in India, with the reservation that these diagnostic characters are not as sharply marked as in other orders and that, outside the larger families, the logical use of these characters in referring an obscure beetle to its family may lead the student astray; if a beetle is shown to belong to a small obscure family, the specimen should be compared with specimens or good figures of others of that family to verify the determination. In Coleoptera more than in all orders, it is very difficult to place specimens that evidently do not belong to the larger families, owing to our ignorance of the Indian representatives of the smaller families.

In no order is the mere rudimentary sorting out of species into groups rendered so difficult as in this, not merely because of the complexity of the order, but because of the want of agreement among those who study this order. Had the general body of Entomologists any "business sense," a working scheme of classification to last, say for 50 years, would have been evolved and then the necessary and radical changes caused by further knowledge made at once; as it is, two authors disagree in a striking manner; they adopt fresh groupings arbitrarily and the student is from the commencement bewildered with conflicting terms.

For our purpose, a knowledge of the main lines to be adopted in the Fauna would have sufficed, but failing this, we have adhered to the classification given in Sharp's Insects, the standard in our work for the past, with a modification from Ganglbauer's views as presenting no radical changes and as possibly anticipating future views. The earlier authors based the main divisions upon the antennal and tarsal characters and it is only lately that authors have gone deeper into the matter and used both the wing venation and internal characters. This is, from the systematist's point of view, an advance, and those who wish to study the relationships of beetles will do well to consult the paper by Ganglbauer (Munchener Koleopterologische Zeitung. Vol. I): unfortunately such characters are useless in every-day work of classifying and arranging specimens and we have been compelled to disregard this aspect in the endeavour to give characters which can actually be used in sorting out ordinary collections. The result is, that while nine-tenths of a collector's captures will be readily sorted and placed, there will always remain a proportion which cannot be so placed; to those who wish to go more deeply into the subject, we recommend the voluminous literature; to those who simply want to know where to place the specimen, we would suggest sending it to Pusa. For ordinary daily working purposes, almost every beetle can be placed at sight in a family at least; to keep pace with changes in classification, to be able to place all beetles more or less accurately, one would have to drop all other work and become an expert in this one subject, a matter of many years of study. We have tried to give the essentials only of such a study.

A complete list of families will be found at the commencement of the volume where we have placed important families in heavy type, and families not known to be represented in India in italics. We have not tabulated sub-families in this list as these divisions do not imply groups of insects so distinct in habits or structure that the student should take heed of them.

Apart from the naturalists who collected in India or obtained specimens from this country in the early part of last century, and whose work laid the foundation of our knowledge of the common species, the work of a limited number of collectors in recent years requires notice. Thus, Father Cardon collected in Chota Nagpur and Kurseong (see Ann. Soc. Ent. Belge., 1890—1894); the collections of Messrs. T. R. Bell in Canara, of H. E. and H. L. Andrewes in the Nilgiris, Anamalais and other South Indian hill districts (loc. cit., 1895—1905), of Doherty in Manipur, Burmah, etc., the visit to India of Mons. Maindron (see Ann. Soc. Ent. Fr., 1903 onwards) and the visit of Mons. Harmand to Darjeeling (Ann. Soc. Ent. France, 1903, p. 108) have borne fruit in description of new forms, in lists of existing known species and so on; these collections, however, scarcely affect the real India (Mons. Maindron's visit alone excepted), since the insects collected were from hill localities like Darjeeling with its temperate climate and fauna; the same may be said of Signor Fea's visit to Burmah in another sense (Ann. Mus. Genova, 1892 *et seq.*) and of the visits of Mr. Lewis, Mons. Simon and Dr. Horn to Ceylon. The student of the fauna of "British India" will owe a debt to these workers, but there have been scarcely any such workers in India proper.

We have endeavoured to refer to most important papers or to give some clue to where the student may find literature: but this literature is practically wholly concerned with systematic work and descriptions of new species; the student will look in vain for any biological work, of any kind almost, prior to the beginning of this century and it is yet to be done. There is an abundant field here for observers and, it is no exaggeration to say, that while thousands of forms have been examined, described, named, listed and put away in Museums, we have accurate data of the lives of not one in a thousand of these species.

We have had, therefore, to confine ourselves in these pages very largely to generalities, and we do this simply to guide the student and would-be observer in the direction he will probably have to go. Where we have accurate data, they are given in such detail as is possible, which must of necessity be brief.

LAMELLICORNIA.

The tarsi are five-jointed, the antennæ have the apical joints dilated at one side, so that a more or less compact club can be formed by the approximation of the lamellar expansions.

It is only in very rare cases that any confusion as to this well marked division can arise and these beetles are readily distinguishable at sight. The number of species is large, nearly one-tenth of the known species of Indian beetles coming into this series. They are commonly divided into three families, ***Passalidæ***, *Lucanidæ* and *Scarabæidæ*, the last divided into five sub-families. It is, however, better to distinguish the *Coprinæ* as a separate family, and we have here adopted the arrangement into four families, retaining the name *Scarabæidæ* for the *Coprinæ*. The arrangement is as follows:—

I. ***Passalidæ***.—Antennal club imperfect. Elytra covering the pygidium. Labrum large and mobile.

II. ***Lucanidæ***.—Antennal club imperfect. Elytra covering the abdomen. Labrum small and indistinct.

III. ***Scarabæidæ***.—Antennæ fully clubbed. Elytra not covering the pygidium.

1. ***Coprinæ*** (*Scarabæidæ*).—No abdominal spiracle visible outside the elytra, all being on the connecting membranes of dorsal and ventral plates, in one line.

IV. (*Melolonthidæ*) 2. *Melolonthinæ.*—Three basal spiracles on connecting membranes, three apical slightly diverging and usually one visible beyond the elytra.

3. Spiracles in two lines, three on connecting membranes, three visible outside the elytra, on ventral plates.

   (*a*) *Rutelinæ.*—Claws of tarsi of unequal size.

   (*b*) *Dynastinæ.*—Claws equal. Fore coxæ sunk, not prominent.

   (*c*) *Cetoniinæ.*—Claws equal. Fore coxæ prominent. (Scutellum large).

This arrangement is in accordance with the larval and imaginal habits as well as with the structure. The habits may be summarised as follows :—

Passalidæ, Lucanidæ.—Larvæ feed in decaying wood.

Scarabæidæ.—Larvæ feed in dung. Imagines feed on dung.

Melolonthidæ.—Larvæ in soil feeding on the roots of plants, in decomposing vegetable matter, in manure heaps, in ants' nests. Imagines feed on leaves, or on flowers.

In this group the larvæ are all white, soft, curved in ventrally, and much wrinkled, with a brown head, no ocelli as a rule, three pairs of well-developed legs and usually a much developed apical abdominal segment. This type of larva (Scarabæoid) is found also only in *Ptinidæ*, and some case-bearing *Chrysomelidæ* (*Clythrinæ*).

PASSALIDÆ.

Lamellicorn beetles in which the antennæ, in repose, curl to bring the lamellæ together and in which the elytra entirely cover the abdomen. Labrum large and mobile.

These beetles are, as a rule, generally recognisable from the general form. They are brown or black insects, in length up to one inch, prothorax large, flattened and shiny, the elytra elongate, with ten lines of punctures, and entirely covering the abdomen. A few Indian species are cylindrical. All are a shining brown or black, the dorsal surface glabrous ; none are very small, most are of moderate to large size. The head is in some species distinctly roughened and knobbed above; the characteristic antennæ are folded back under the head or are extended in front; the large toothed mandibles meet just beyond the edge of the clypeus. The legs are strong, the fore tibiæ broadened and suited to digging, the posterior legs more slender, the tibiæ with long brown hairs. A feature of these, as of other lamellicorn beetles which live in decaying vegetable matter, is the presence of abundant fine brown hair on the legs and lower surface of the body.

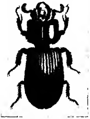


Fig. 138.—BASILIANUS STOLICZKÆ.

The larvæ of insects of this family are found in decaying wood in forests and are large fleshy insects, similar in form to other Scarabæid larvæ, with the first pair of legs reduced in size and functioning as stridulating organs. The anal opening is transverse, the upper lip indented longitudinally. The imago lives also in decaying wood, under the bark of trees and among decaying vegetation. They are most abundant in forests and not found in the cultivated plains. A caustic fluid is secreted by some species, serving probably as a protection. They are almost wholly forest species and may be met with rarely in moister cultivated areas of East and South India, not in the dry plains.

Stoliczka remarks that *Passalidæ* are met with only in parts of India with a Malayan fauna; he lists 23 Indian species, from South India, Eastern Bengal, Burmah, etc. *Basilianus* is the commonest genus. (J. Asiat. Soc. Bengal, XXII, p. 149.)

LUCANIDÆ.—*Stag Beetles.*

The antennæ do not curl, the club being indistinct; the elytra cover the abdomen, the labrum is small and indistinct.

Beetles of large size in which the simplest distinguishing character is the large mandibles of the males, which project forward as two large and formidable jaws. These are, in the female, of moderate size and not conspicuous. None are small insects, the length varying from 1½ inches to over four. The colouring is brown and black, as a rule, sombre and dull as in other beetles of similar habits.

These beetles are somewhat flattened, the head large, the antennæ moderately long; in the commonest species the eyes are divided by a projecting ridge, producing a small upper and a large lower eye. The prothorax is large and smooth, the elytra is smooth and shining. The legs are long, the tibiæ broadened, the tarsi long and conspicuous.

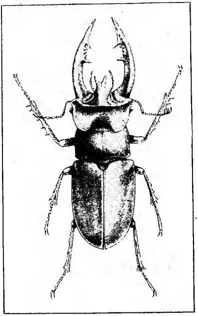


Fig. 139.—LUCANUS LUNIFER, MALE. [I. M. N.]

The beetles live in decaying trees and the males fly at night. The function of the very large mandibles is not always apparent and it is not clear that they use them; there is great variation in the degree of their development and intermediates from those resembling females to those with fully developed mandibles are found. (See page 189.)

The female lays her eggs in a decaying tree, the larvæ living upon decaying vegetable matter. The larva is a large fleshy insect, distinct from Passalid larvæ by the equal development of three pairs of legs and the longitudinal anal slit, closed by two lateral lips.

Lucanidæ are widely spread and find their greatest development in the Eastern Himalayas and Assam, where a great number of species, often of large size, occur. They do not occur in the plains and no species require mention. We figure *Lucanus lunifer*, Ho., one of the commonest in the Himalayas. Westwood figures a number of the Indian forms (Cab. Or. Entom., 1847). No species are of economic importance.

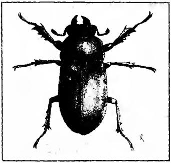


Fig 140.—LUCANUS LUNIFER, FEMALE. [I. M. N.]

Thomson (Ann. Soc. Ent. France, 1862, p. 392) lists 36 Indian species which are only a proportion of the known species. The principal genera are *Lucanus*, *Hexarthrius*, *Cladognathus* and *Dorcus*. Parry catalogues the family in Transactions of the Entomological Society, London, 1864, pp. 1—113, listing 70 Indian species. Felsche published a later catalogue in 1898 on which Boileau's remarks should be also seen (Ann. Soc. Ent. France, 1898, p. 401), and since then Albers listed the Kurseong species (Ann. Soc. Ent. Belgium, 1903, p. 69). Altogether about 100 species are recorded; some of these may prove to be forms of the same species, the great sexual differences having led to the multiplication of species founded on an insufficient number of specimens.

SCARABÆIDÆ.—*Dung-Rollers.*

Antennæ with a knob of closely folded leaflets. Elytra not covering the pygidium. Spiracles in one line, on the connecting membranes and all covered by the elytra.

A large group of small to large beetles, usually of sombre colours, some few metallic blue or green. The body is round, thickset, the head projecting forward as a flat plate, beneath which are the mouth-parts. The prothorax often has projections and the head a process or spine, or a number of teeth on the anterior edge. The hard rough elytra cover the abdomen completely, with the exception of the pygidium. The legs are large and powerful, the tibiæ broadened and spined at the apical half, the tarsi slender. In the larger species the fore tarsi are commonly absent. The robust spherical body, the large broadened legs, the platelike head, the spines or projections on head and prothorax are extremely characteristic, and the bodily structure is specially modified in connection with the peculiar habits.

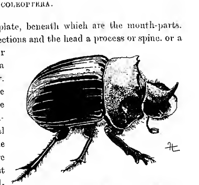


Fig. 141.—HELIOCOPRIS BUCEPHALUS, MALE. [F. M. H.]

Throughout this large sub-family the habits are, so far as known, fairly uniform. The beetles collect in dung, feeding upon it and making it into balls which they roll over the surface of the ground and take into the soil, where they either feed upon it or use it as food for their young, dividing it into portions in each of which an egg is laid, and which the larva inhabits and gradually eats. The flat head is used as a shovel in these operations, digging out the food, shaping it and consolidating it; the long legs assist the beetles in rolling these pellets over the ground and the digging forelegs aid in excavating or enlarging holes in the ground. In the dry hot weather, dung of cattle attracts great numbers of these beetles and the spot becomes lively almost at once with these active and energetic insects. It is a common sight to see beetles rolling these pellets, usually larger than themselves, rapidly along the soil and their antics are usually very grotesque. All do not roll dung, some (the smaller species) making a tunnel below the mass of dung and carrying down what they require. The end of the tunnel is filled with dung fairly closely packed; the beetles either feed upon it, remaining over it and devouring it while a long mass of excrement is deposited, or they lay an egg in it, the white footless grub feeding in the mass. April to June seems to be the period of greatest activity of the beetles, but the details of the life-history of few Indian species have been observed, and many forms fly in the rains. Elsewhere careful observations have been made and the extremely interesting accounts of M. Fabre should be read by every student. (There is an English translation of M. Fabre's first volume entitled "Insect Life;" the original volumes are in French, under the title "Souvenirs Entomologiques"). Major Popham Young sent a large ball found eight feet below the surface of the soil in Patiala when excavations were being made for a house, which was evidently the ball containing the larva of a large Copride. Sykes gives an account of the finding of the immense balls made by *Heliocopris midas* in Poona in the soil. One ball remained thirteen months before the imago emerged, another sixteen months. During this time the insect was in the larval and pupal stage, and the life-history would occupy probably two years. (Trans. Ent. Soc., London, Vol. I, p. 1835.) A few (*Onthophagus*) attack decaying animal matter and these are the little beetles which so promptly remove the larger dead insects; the disappearance of dead locusts is marvellously quick, and the powers of smell of these beetles must be very acute to bring them so quickly to the scene. A few are found in decayed trees. The larvæ are never seen and live below ground.

The members of this family exercise a very important function in the economy of nature; not only do they cleanse the surface of the earth of the excrementitious matter deposited on it, but they carry into the soil quantities of this valuable manure that would otherwise become dessicated on the surface and with the first heavy fall of rain, would be washed away and carried down in the streams and rivers to the sea. A very great quantity of manurial matter is probably rendered available in the soil by the activities of these insects, and though it is not possible to definitely estimate the effect of their work, it is certainly a very considerable one. Species have been imported to the Hawaiian Islands in the hope that, by destroying the droppings of cattle quickly, they may reduce the numbers of the Hornfly (*Hæmatobia serrata*) which breeds there.

Sound is produced in a variety of ways, by friction of two parts of the body. In *Bolboceras*, the male has a corrugated expansion of the lower surface of the head, and by moving his head up and down, he rubs it against the edge of the pronotum, producing a squeaking noise

In *Trox* the abdomen rubs against a raised vein in the elytra. In *Heliocopris bucephalus*, sound is produced by a rotation of the hind coxa, the posterior and internal edge rubbing against the sharp edge of the socket and producing a curious "wheezing" noise.

This large family may be divided into seven sub-families as follows:—

I. Antennæ 9 or 10 joints :—		
A. Posterior legs with one spur.	1.	*Scarabaeinæ* (*Coprinæ.*)
a. Posterior legs dilated gradually.		*Scarabaeini* (*Ateuchini.*)
b. Posterior legs dilated suddenly.		*Coprini.*
B. Posterior legs with two spurs.		
a. Metathoracic parapleuræ simple.		
Antennæ 9 joints.	2.	*Aphodiinæ.*
Antennæ 10 joints.	3.	*Orphninæ.*
b. Metathoracic parapleuræ appendiculate.	4.	*Hybosorinæ.*
II. Antennæ 11 jointed.	5.	*Geotrupinæ.*
III. Abdomen with five ventral segments.	6.	*Troginæ.*
IV. Tarsi very long.	7.	*Glaphyrinæ.*

Scarabaeinæ.—Four large genera are included in the *Scarabaeini* (Ateuchinæ) with over 30 Indian species. *Scarabaeus* (Ateuchus) includes some of the larger European forms, and but few Indian. *S. gangeticus* Redt. is the common plains species. *Sisyphus* and *Gymnopleurus* include the common small beetles with long legs found at dung in the plains. *S. longipes*, Oliv., is one of the more abundant species, a small black insect common on roads in April; it makes balls of dung about twice its own size; usually two are found at one ball, rolling it along the soil, and they have been seen to take a ball over a hundred yards. *Gymnopleurus miliaris*, Fabr., is also common ; it is dull black with shiny black spots on the elytra and thorax. *Gymnopleurus cyaneus*, Fabr., is the metallic blue species that may constantly be observed rolling dung balls. When a ball is made several assist in rolling it, apparently in the hope of securing it ; the stronger individual appears to be successful in the end, rolling the ball to a spot where the soil is loose and then, by digging the earth away below it, burying it to a considerable depth. *Caccobius* includes five species, one occurring in the plains and of which nothing is known. *Coptorhina* and *Caccophilus* occur in the hills.

Coprini.—The majority of Indian species are included in this division, over 100 species occurring in India proper. *Catharsius molossus* Linn., *C. sagax*, Quens., and *C. sabaeus*, Fabr., are common, moderately large black insects that fly at night and come freely to lights in the rains. *Copris* is represented by *C. repertus*, Wlk., which flies in the hot weather and at the first rain. *Heliocopris bucephalus*, Fabr., and *H. gigas*, L. (midas F.) are the giants of the family, large thickset beetles with very powerful legs and greatly chitinised prothorax. *Onitis* is well represented, moderate-sized beetles, of an olivaceous brown tint, without the exuberance of horns and tubercles of the previous genera. *Onthophagus* comprises a very large number of usually small forms with very varied developments of horns and tubercles in the males. They are common in the dry hot weather and while some come to dung, others feed on dead insects; the abundant locusts that died after egg-laying at Igatpuri in June

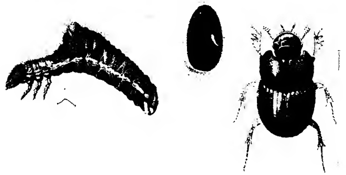


Fig. 142.—ONTHOPHAGUS LONGICORNIS: LARVA, EGG IN BALL, IMAGO.

1904, were fed on by *Onthophagus gravis*, Wlk., and the bodies very quickly destroyed. *Onthophagus longicornis*, Deyr., has been reared from larvæ found in balls buried to a depth of three to five inches below the surface immediately under cowdung. Each ball is oval, the long axis about twice the short, about ¾ inch long. This ball is hollow, and the single white egg is fixed inside. The larva feeds on the ball, leaving the coarser outer shell and then pupates within. The larval life lasts for 21 days and the total life from egg to imago is, in May and June, about 5 weeks. At other seasons these beetles are found in the soil. Many of our commonest plains species are undescribed and no observations appear to have been made on their habits. Over 60 species are recorded and many remain to be described. *Oniticellus cinctus*, Fabr., a black species with yellow fasciæ, and *O. pallipes*, F., a dull brown species, are abundant in the plains; the latter has been reared from eggs found in dung-balls buried three inches underground. The eggs are attached each to one end of the cavity in an oval ball; the larva has the first few segments of the abdomen much drawn out and enlarged, apparently for the reception of the alimentary canal which is more than double the length of the body and bent back upon itself more than once, being also very capacious and filled with food. In habits and appearance it differs little from that of *Onthophagus longicornis* described above. The larval and pupal life together occupy about 19 days.

Drepanocerus is represented by the tiny *D. setosus*, Wied., common in cowdung.

Aphodiinæ.—These beetles feed in dung, the larvæ being found in the dung-mass. They are small, brown or black species, cylindrical in form and readily confused with the Carabids of the Scaritine division. *Aphodius* is the principal genus, with over twenty Indian species recorded; they are extremely abundant in the rains coming to light in great numbers. *Aphodius* has been reared from larvæ found in a dung ball below ground. Three larvæ inhabit one mass, the eggs they hatch from being laid in different parts of the ball. The larvæ are of the typical form, white, wrinkled and bent, with well developed legs. They pupate in round black cocoons, apparently made of excrement, emergence taking place partly by biting through the cocoon, partly by bursting it. Larval and pupal life together occupy about sixteen days in July-August.

Rhyssemus includes very small species, resembling Scolytids; *Rhyssemus germanus*, Linn., is the common species in Bengal and Behar, and has been seen flying in very great numbers in warm still evenings in March. *Chætopisthes* is recorded by Wassmann from nests of *Termes obesus* in India and may be obtained by digging into the large central nests and fungus chambers.

Orphninæ.—*Orphnus* and *Ochodæus* are Indian, with several species. *Orphnus picinus*, Westd., is common in the Himalayas, where it makes tunnels in the soil below masses of cowdung, carrying the dung down to fill the ends of the tunnels, its larvæ being found in the dung-mass.

Hybosorinæ. Represented by *Hybosorus orientalis*, Westd., and *Phæochrous indicus*, Westw., the latter not uncommon in the plains. It is a flatter insect, with the appearance almost of a Tenebrionid.

Geotrupinæ.—These are nocturnal insects, found abundantly in the rains and coming freely to light. Their habits appear to be practically unknown in India; Boucomont says of the group in general that they dig long vertical tunnels in the soil where they remain by day, and where their larvæ live; the beetles feed on dung and fly at night in search of it. *Lethrus* and its allies are remarkable for living in couples in burrows and feeding on the shoots of plants. but none are recorded as Indian. Boucomont has listed the species (Gen. Ins. 1902), mentioning as Indian *Geotrupes* (9). *Bolboceras* (26), *Athyreus* (2), *Ceratophyus* (1). *B. quadridens.* F., and *B. subglobosus*, Westw., are our common forms.

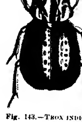


Fig. 143.—Trox indicus.

Troginæ.—Four species of *Trox* occur. (Harold Col. Hefte, IX. p. 1), the common plains forms being *Trox indicus*, Hbst., *T. omacanthus*, Har., both quite common. They feed on hard dry excrement, which appears to be their normal food, with small carcases and dead insects.

MELOLONTHIDÆ.

Antennæ with a knob of closely folded leaflets. Elytra not covering the pygidium. One or three spiracles visible beyond the elytra.

This very large family includes the familiar cockchafers, moderately large thickset beetles, the head small, the prothorax large and rounded, the abdomen, with the elytra, hard, round and robust. The forelegs are commonly broadened and fitted for digging in the soil. The posterior legs are strong, often well spined. Wings are present and the beetles fly well. The tracheæ contain dilations which are inflated before flight, thus increasing the volume and reducing the specific gravity of the insect as a whole. Stridulation of one hard part of the body against another is frequent, a variety of sounds being produced. Sexual distinctions are well marked in some by prominent secondary characters. The larvæ are fleshy soft grubs, the body wrinkled and curved in an arc; the head is large, the apical abdominal segment very much developed. Legs are present but are little used. The four sub-families are distinct; their characters are enumerated above (page 242).

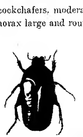


Fig. 144.—THAUMASTOPEUS PULLUS, × 1.

MELOLONTHINÆ.—*Cockchafers.* Moderate-sized beetles, with robust bodies, the elytra covering all but one spiracle, the legs only slightly broadened and without horns or spines on head and prothorax. These are mostly dull-coloured insects, brown predominating in the colouration, and they vary in length from a quarter of an inch upwards. The antennæ are short, with the knob composed of one more joint in the male than in the female, the leaflets also longer in the males; the prothorax is small, the elytra generally smooth and fitting tightly to the abdomen. The legs are moderately long, fitted for walking and to a less degree for digging.

The life-history of no Indian species is recorded in any detail. Generally speaking, the larvæ live in the soil, feeding upon the roots of plants. They are fleshy dingy-white in colour, the head brown, the body curved in an arch and the apical segment large and smooth. There are many folds in the skin and three pairs of short jointed legs. The mouth-parts are of the usual mandibulate type and the food is principally roots and underground plant tissues. The larva moves actively in soil, but is comparatively helpless on the surface, the curved body interfering with locomotion. When full-grown it makes a mud cell and transforms to a pupa in the soil. The length of the life-history is not known and may occupy one, two or three years as it does elsewhere though there is at present no reason to believe it occupies longer than one year. The imago flies by night and comes to light. The forewings are not moved in flight but are held rigidly and apparently serve for a parachute and as directors of flight. The food consists of vegetable matter, leaves and flowers being eaten at night, the beetles hiding by day. Few are active by day, but some may be found clinging motionless to grass stems.

The destructive species are so on account either of the destruction to roots by the larva, or the destruction to leaves or floral organs by the imago. In Europe immense numbers of *Melolontha vulgaris* constitute a very formidable pest in both stages and immense multitudes of these insects occur. Nothing of this kind has yet been observed in India, and, though species are plentiful, the enormous multiplication of any one species does not seem to take place and the place of the *Melolontha* in Europe is here taken by the Rutelid *Anomala*. The grubs of *Melolonthidæ* are the prey of *Scoliidæ* which seek them out and lay their eggs upon them, after they have been parasitised by stinging.

The number of species is very large and no complete list of Indian species exists. A number were described and listed by Brenske in Indian Museum Notes. The classification of such large numbers of insects is a very difficult matter and the sub-family as a whole is not studied to the extent it deserves. The identification of Indian forms is possible only by systematists with large reference collections and libraries at hand and cannot be undertaken at present. The more common species of the plains are figured (I. M. N.) and we can only advise collectors to collect patiently, to sort out their specimens into species under numbers and hope to get them identified as occasion may offer. The species of the Indian Museum were listed by Barlow (Indian Mus. Notes, IV, p. 231). The *Hoplini* include only *Hoplia* and *Ectinohoplia* with less than twenty species mostly hill forms. The *Sericini* have been monographed by Brenske (Die Serica-Arten der Erde) with 103 Indian species. *Serica* *lugubris*, Brsk., is a moderate-sized black species found commonly at light in the plains. *S. indica*, Blanch, has been reared from larvæ feeding on the roots of cane in Behar and is one of the most common species. *Macrodactilini* include one species, *Dejeania alsiosia*, Bl., a moderate-sized brown pubescent species which is found in the plains in June. The *Melolonthini* include over 160 species. chiefly in the genera *Apogonia*, *Schizonycha*, *Lepidiota*, *Holotricha* (Lachnosterna), *Bramina*, *Hoplosternus* and *Melolontha*. They are the larger cockchafers of the plains, most abundant in the moister areas. *Apogonia carinata*. Brsk., is a shiny black species of moderate size which is found passing the winter under the bark of trees. *A. proxima*, Wat., is extremely like it and is found flying in June. *A. uniformis*, Bl., is also common, a smaller brown species which comes freely to light during the rains. *Schizonycha xanthodera*, Bl., is a larger species, which flies during March and April. *Lepidiota* includes the very large species found in forest localities as a rule; one species *L. rugosipennis*, Bl., is found in the plains, though rarely.

Rutelinæ.—Lamellicorn beetles, with three spiracles on the membrane between the dorsal and ventral plates, three on the ventral plates and visible, with the claws of the tarsi of unequal size. These are moderate-sized insects. in general form closely similar to the Melolonthids. Many are brightly coloured, blues. greens and browns predominating, and many are sombre.

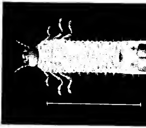
The life-history of one species is known, this being the common cockchafer of the plains, *Anomala varians*, Oliv. The stages are fully illustrated in Plate XIV and the details of the life-history are given in full elsewhere. (Mem. Agri. Dept. India, Vol. 11.) The life-history occupies one year ; eggs are laid in the soil in the early rains, which increase in size and weight after laying. The larva lives in the soil eating the roots of rice, bajra and other cereals. It rests in the soil from September. pupates in March, April or May, and the imago emerges, after about ten days.

A large number of species occur in India, one subdivision, the *Anomalides*, being distributed through the tropics, another, the *Adoretides*. abundant in India and Africa alone. *Anomala* with over fifty species, *Popilia* with thirty and *Mimela* with twenty-seven are included in the first; *Adoretus* with twenty-four species in the second. To a greater

PLATE XIV.—ANOMALA VARIANS.

THE COCKCHAFER.

Fig. 1. Egg when laid.
,, 2. ,, just before hatching.
,, 3. Larva, dorsal view.
,, 4. ,, lateral ,,
,, 5. Pupa, dorsal view, in the last larval exuvium.
,, 6. ,, ventral view.
,, 7. ,, lateral ,,
,, 8. Imago.



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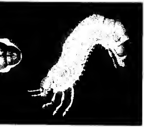

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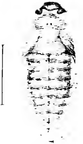

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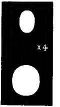

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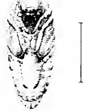

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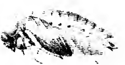

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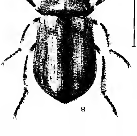

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extent even than other groups, these are hill forest insects, very few occurring in the plains proper. *Anomala pallida*, F., and *A. varians*, Oliv., are common in the plains, both brown species like cockchafers. *Anomala viridis*, F., is the common green *Rutelid* found outside the hills, the remainder being mainly hill and forest species. *Anomala dorsalis* Fabr., was reported from the Victoria Garden, Bombay, as destructive to *Crinum latifolium* (Indian Mus. Notes, Vol. V, p. 130). *Pseudosinghala transversa*, Burm., is the small black species which comes up from the soil in myriads in May in the Khasi Hills and destroys flowers. *Adoreta cardoni*, Br., is recorded as destructive to rose bushes and cultivated plants in Calcutta (Indian Mus. Notes, Vol. IV, p. 136).

DYNASTINÆ.

These insects have the characters of the *Rutelini*, but are distinct in the labrum, which is not visible from above in this sub-division, and in the equal tarsal claws. They are usually large insects, the males with a horn on the head, and a tubercle or projection of some nature on the prothorax. The colours are usually dull, black and brown predominating; the body is usually massive and thick, and the giants of the insect world are here included. The males stridulate by moving the end of the abdomen in and out, by which the apical edge of the elytra rubs against a file on the upper surface of the abdomen. The larvæ are found in old trees, in decomposing vegetable matter and in soil rich in humus among plant roots. The pupa is enclosed in a hard case and the metamorphosis is believed to be long.

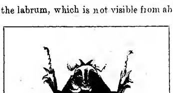

FIG. 145.—ORYCTES RHINOCEROS MALE.

India, America and Africa contain the majority of species, the number of Indian species not being large, probably less than 60 in all. *Oryctes rhinoceros*, Linn., is one plains species, found throughout the cultivated plains where toddy, cocoanut or other palms are grown. The beetle flies by night and eats into the soft tissues of the apex of the growing palm; in eating through the folded developing leaves it makes tunnels which are shown by ragged holes in the leaves when they open. Frequently the growing bud of the palm dies, growth is stopped and the whole palm withers. The insect is known by a variety of names in most parts of India where its ravages are known; the toddy-drawers know it and often know that its grub can be found in a heap of decaying vegetation or in a decaying tree. These larvæ are fat soft grubs, with a much wrinkled body, and as the tissues inside move, the whole suggests a well stuffed soft pillow in which is a small struggling animal. *Phyllognathus dyonisius*, F., is the only other common *Dynastid*. The life-history of this has been worked out from specimens sent in by A. M. T. Jackson, Esquire, I.C.S., as destroying rice in Belgaum. It is fully illustrated in Plate XV and has been fully described elsewhere (Mem. Agric. Dept., India, Entom., Vol. II). Shortly, the eggs are laid in soil in the commencement of the rains (June-July), the larvæ are mature by September and pupate, the imago emerges in October and remains in the soil until May, when it comes out. The larvæ behave like typical cockchafer grubs, feeding on the roots of plants.

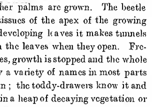

Fig. 146—ORYCTES RHINOCEROS, LARVA.

CETONIINÆ.

Moderate-sized insects, often of brilliant metallic colouring; the form of the body is slightly flatter than in the *Melolonthidæ* and the scutellum is often large. The males are rarely distinguished by prominent characters, such as horns, and the two sexes are closely similar in the common species. The colouring is very striking, metallic green in some, brown with varied yellow markings in others; and in conformity with this, many are diurnal species which are seen on flowers. The life-history

PLATE XV.—PHYLLOGNATHUS DIONYSIUS.

THE RICE COCKCHAFER.

Fig. 1. Egg, when laid and just before hatching.
" 2. Young larva, dorsal aspect.
" 3. " " lateral "
" 4. Adult " dorsal "
" 5. " " lateral "
" 6. Pupa, ventral aspect.
" 7. " dorsal "
" 8. " lateral "
" 9. Imago, female, dorsal aspect
" 10. " male, lateral "

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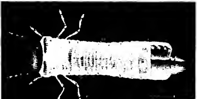
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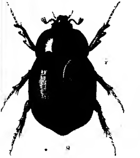

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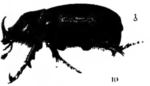

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is practically unknown in India; the larvæ are in general similar to those of other *Melolonthid* beetles, and live upon decaying vegetable matter or roots, or in ants' nests. The beetles are commonly diurnal, flying actively close to the soil under the trees of forests. They are often to be seen in abundance on a fine day in the rains in suitable localities.

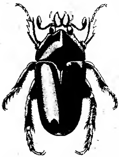


Fig. 147.—THAUMASTOPŒUS PULLUS, × 2.

There are a large number of species in India and throughout the tropics. They are distributed chiefly in forest areas but extend into the plains and form part of the general plains fauna. Janson (Tr. Ent. Soc., London, 1901, p. 179), lists the *Cetoniids* collected by Andrewes and Bell in the Bombay Presidency: twenty-seven species are enumerated, of which twenty are confined to South India, four are found also in North India, and three widely spread outside India. The volume in the Fauna of India (now in the press) may be consulted. Nearly 200 species are described from India, exclusive of Ceylon. Four sub-families are recognised :—The *Euchirini* with *Euchirus*, an anomalous insect confined to the Himalayas; the *Cetoniini*, including the majority of the species, the *Valgini* with less than ten species and the *Trichiini*, with a small number of species of *Trichius*. Both sexes of *Eucheirus macleayi*, Ho., are figured by Westwood (Cabinet of Oriental Entomology). The enormously long curved forelegs of the male are the most striking feature of this insect, which is found in Assam and the Eastern Himalayas only.

Naricius opalus, Dup. is a metallic green species in which the head is produced into two porrect horn-like processes. In the brown *Dicranocephalus wallichi*, Ho., this process is branched, curved and like a stag's antlers. *Rhomborrhina* includes the large metallic species common in and near forests. *R.* (Torynorrhina) *opalina*, Ho., has the head produced in a flat plate. *Heterorrhina amana*, Ho., is a delicate yellow-green insect with lines of black punctures on the elytra, found rarely in grass in the plains. *Clinteria* includes several green, brown or black species marked vividly in white or orange spots. *C. spilota*, Ho., is the variable species so abundant on grass in the hills. *Thaumastopœus pullus*, Billt., is a large shiny black insect found in Behar. In this species the prominent mesosternal process which projects forward between the fore coxæ towards the mouth is conspicuously shown. *Macronota* is well presented in South India by species with vivid yellow lines on the pronotum, elytra and abdomen ; the elytra taper a little and the abdomen projects conspicuously at the sides. *Glycyphana albopunctata*, F., and *G. versicolor*, F., are found in the plains, abundantly near forests. *Oxycetonia albopunctata*, F., is the brown species found sometimes in abundance at the flowers of cereals, with the green *Chiloloba acuta Wied.* In the Central Provinces both these species have been destructive, feeding on the anthers and stigma of juar, rice and millets. The latter is a beautiful pure green insect, with very marked golden pubescence. *Protætia alboguttata*, Vig., is a conspicuous deep blue insect with vivid white spots, found throughout India. The pupæ have been found at the roots of trees, in cases composed of pellets of mud or excrement outside, smoothed mud or excrement within. *Anthracophora atromaculata*, F., is the large dingy black and white species found widespread over India.

Collecting.—Every possible member of these important families should be collected; it is unnecessary to pin at once, as beetles keep well in clean sawdust, free of dust, with enough naphthaline to prevent mould. For collecting there are two methods, the net or fingers by day, the lamp trap by night. It cannot be too strongly insisted that since these insects emerge often only once a year, dates of capture are of extreme importance. Beetles are pinned through the right wing case; I have not found it necessary to remove the soft parts, but it is advisable to soak the dried insects in benzene to remove grease. Larger ones must be very carefully dried. Scarabæids are best got in the hot weather at their food and in this group careful observation and study of habits is required. Rearing is possible if the dung balls are obtainable. Melolonthids can be reared in earth if given roots enough and carefully tended. They thrive in soil in which plants are grown, *e.g.*, rice and can then live and feed under normal conditions.

ADEPHAGA.

This series is by Ganglbauer and others separated from all other Coleoptera on account of the wing-venation, the details of the internal anatomy, and the fact that the larva has two-jointed tarsi. It includes ten families, of which six are commonly found and should be familiar.

CICINDELIDÆ.—*Tiger Beetles*,

The clypeus extends laterally in front of the insertion of the antennæ. The maxillæ terminate in an articulated hook.

With few exceptions, these beetles are generally recognizable in the field from their general form, which is distinct from that of their allies, the *Carabidæ*. They are often brightly coloured, green, brown or black with spots or bands of white being most common. The majority are from one-half to an inch long, few under or over these limits. The head is short and thickset, in *Collyris* (Plate XVI, Fig. 11), constricted behind the eye into a neck; the eyes are prominent, the antennæ moderately long. Long curved mandibles project in front of the head, the maxillæ and labium being conspicuous, the whole mouth-parts evidently of the predaceous type, formed for rapidly seizing and firmly clasping the insects they feed upon. The prothorax is large and cylindrical, the elytra usually smooth or only finely pitted. There are many wingless species, and some are very distinctly pubescent. The legs are long, slender, finely spined and formed for rapid running. The sexes are alike, the three basal segments of the male tarsi often elongated, while the males show six, the female seven visible ventral segments.

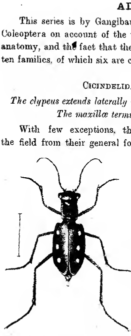


Fig. 148.—CICINDELA SEXPUNCTATA.

The life-history is believed to be uniform throughout the group, and larvæ that can be referred with certainty to this family have been found in India; these larvæ are found in vertical burrows in the wet sand or mud near rivers; apparently they require wet material which admits of the formation of a burrow, but their choice of locality may be determined by their prey; the burrow extends vertically from the surface and the larva can move up and down by means of the legs and a dorsal hump or projection; the head is flat, used to carry up the soil when excavating, and the very long jaws are turned backwards and upwards, so that when the flat head is blocking the upper end of the tunnel, the jaws have free play above and are in a position to seize any unwary insect that alights or walks within reach. The length of the life-history has not been ascertained, but as each species appears to emerge in the imago form for a definite period in the year, it is probable that the life-history occupies one year or multiples of one year; the imago lives for several weeks. The student should read the life-history of *Cicindela campestris*, an English insect, which occupies three years (Proc. Ent. Soc., London, 1903, p. XV). R. Shelford figures the curious larva of *Collyris emarginatus*, Deg. from Java, which lives in burrows in coffee stems, feeding on the insects that go past. The larva has on the fifth abdominal segment six hooks, curved forwards, on a protuberance. A similar larva was found in China (Trans. Ent. Soc., London, 1907, p. 83).

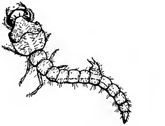


Fig. 149.—CICINDELA LARVA, × 2

The majority of these beetles appear in the rainy months, some at the beginning, some later. Our common species are diurnal in habit, though some are known to be nocturnal. They are among the most active of insects, flying for short distances with great rapidity and also running quickly. So far as known all are predaceous on other insects, though their exact economic value is difficult to ascertain. Maindron records that *Derocrania longesulcata*, Mon., feeds on *Silis* (Drilinæ), and such records of food are noticeable for their rarity. The majority are found in damp places, in rice fields or thick vegetation, on river banks, on the seashore; some are found only on trees in forest localities. Some are known to emit scents, not of an unpleasant character, but which probably serve a defensive purpose in association with the warning colouration.

The family is not a large one and the majority of the species are referred to the genus *Cicindela*. Atkinson's Catalogue (Asiat. Soc., Bengal, LIX, 1890), lists 119 Indian species, *Cicindela* (74), *Pronyssa* (1), *Megalomma* (2), *Dromicidia* (1), *Jansenia* (2), *Therates* (1), *Tricondyla* (5), *Collyris* (32), *Tetracha* (1). Maindron has added others (Ann. Soc. Ent., France, 1899, p. 379); Bates described Lewis' Ceylon forms (Ann. Nat. Hist., VI, 16, pp. 68, 143, 199). A revision of *Collyris* will be found in Ann. Soc. Ent., France, 1864, page 483.

Horn has described others (De. Ent. Zeitschr.), *Cicindela* (17), *Collyris* (10), *Tricondyla* (4), *Therates* (3), *Heptodonta* (2), *Neocollyris* (4), *Calochroa* (4), *Euryoda* (1), *Derocania* (1), *Prothysa* (1), are included in these later papers. Horn is now monographing the family in Genera Insectorum. Of these less than 20 *Cicindela* and one *Collyris* (*C. distincta* Chd.), occur in tropical India generally. *Cicindela sexpunctata*, Linn., is a striking species, found in the rice fields where it preys on the rice bug, *Leptocorisa varicornis*. It appears in August and September. *C. grammophora*, Chd. (Plate XVI, Fig. 12), is abundant in the rains in Behar, the commonest of the small species and very active on wet ground. *C. 4-lineata*, F., is a conspicuous insect with four stripes of yellow on the elytra, found abundantly on the seashore of Western India; in May, it feeds on the *Halobates germanus* so abundantly thrown up on the beach in the strong South-West wind and is a very conspicuous insect. *Cicindela 8-notata*, Wied., is common on the banks of rivers in the plains, a very gaudily coloured and noticeable species. *C. 20-guttata*, Hbst., with ten yellow spots on each elytron is abundant in rice fields with *C. sexpunctata*, Linn.

Collyris includes mainly metallic blue tree-haunting species which are difficult to distinguish; nearly all are forest species, some living on trees and bushes in the plains. *Therates*, like *Collyris*, has a long neck but is apterous, and includes robuster brown insects, found also in forests. The *Cicindelidæ* are often of curiously limited distribution with regard to individual species; the common forms of one part of India are limited to distinct areas and there appear to be few species really widely spread even over the plains. A number of our subtropical species are widespread outside India, and of the species recorded from Sind. many are probably not Indian at all.

Collecting.—These beetles cannot be caught without a good net and should always be killed at once or kept apart till they can be killed. Their larvæ can be found if looked for, but we have not heard of any being reared in confinement. The greatest desideratum is close observation of the food of both larvæ and adults as the actual species they prey on is known in very few instances and until this is known their economic value must be doubtful. They will be found only in moist soil, and are abundant in lands where silt is deposited after flood.

CARABIDÆ.—*Predaceous Ground Beetles.*

Antennæ filiform ; the tarsi all five-jointed, clypeus not extending laterally in front of base of antennæ, maxillæ not hooked.

These beetles are widely distinguished from all others ; the only family with which they are likely to be confused being the *Cicindelidæ* which have the lateral extension of the clypeus in front of the antennæ. The two families are very closely connected and authorities are not unanimous as to their separation. The beetles vary in size from small to moderately large, the smallest one-quarter of an inch long, the largest nearly one inch. The colouring is varied, often black or brown, sometimes with bright patches of yellow, and it is often strikingly warning. (*Anthia sexguttata*). As a whole it is the characteristic sombre dark colouring of ground insects, similar to that of *Tenebrionidæ*, *Blattidæ*, *Forficulidæ*, etc. The body is usually oval, broader than in *Cicindelidæ* and more flattened. The antennæ are filiform, rarely moniliform, not elbowed and projecting conspicuously in front of the head. The compound eyes are large, the mouth-parts conspicuous and long, the biting predaceous type with long curved mandibles. The prothorax is large, the elytra fitting tightly to the body, often with rows of pits or with lines. The body is, as in nearly all *Coleoptera*, enclosed in hard well-fitting chitinous plates, whose morphology is the basis of the classification of this large family. The legs are moderately long, fitted for rapid running or short and thickened, fitted for burrowing, the tarsal joints distinct, the claws well formed. In the males the basal tarsal joint of the fore leg is expanded. The elytra are in some species soldered together and do not open, there being no wings below and flight not being possible. (*Anthia*, *Carabus*). On the ventral abdominal segments are specialised setæ used in rapid locomotion along the ground.

The life-history is almost unknown in detail, but so far as is known elsewhere it is uniform throughout the group and the little known of the Indian species agrees generally. The larvæ are slender active insects, the head large with long mandibles and six ocelli, the thorax and abdomen smooth and tapering, with a terminal pair of dorsal cerci, an anal tube and three pairs of thoracic legs. The terminal processes are fairly characteristic; the colours are black or dull and the carabid larva is an insect that can usually be readily recognised. They are in the main predaceous and constitute part of the surface fauna and are best found when caterpillars are abundant on a crop, when they gather there to feed. Elsewhere some are known to feed in the roots of the crops, and one is a pest, but no record of such vegetarian larvæ exists for the Indian species, which are commonly predaceous. They suck out the juice of caterpillars and other insects, and though they must be extremely abundant, are very rarely found, except under these exceptional conditions. No details are available as to the length of the life-history. Pupation takes place in the soil. The eggs of one species (*Anthia sexguttata*) are large oval bodies, white and soft, measuring nearly one-quarter of an inch in length. One is laid at a time and dissection shows that they develop successively and are produced singly; apparently egg-laying is extended over a long period and the active imaginal life is probably long. The total number of eggs produced is probably small. Hibernation, so far as observed, takes place in the imago stage, the beetles burying themselves in the soil or otherwise taking shelter. Possibly it takes place in the other stages also.

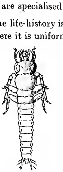


Fig. 150.—HARPALUS LARVA. (*After Packard.*)

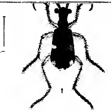
Carabidæ are partly diurnal, partly nocturnal, the latter species sometimes coming to light. Most can produce a caustic mal-odorous liquid from glands opening above the anus; in a few this liquid is volatile, and on being set free goes off with a little report; the enemy being overcome by the odour and detonation, the beetle escapes rapidly. No species is in India known to be destructive, and but very few are possible pests elsewhere, the carnivorous habits of the family apparently giving place to herbivorous habits in a very few species. The family can be classed among the great number of miscellaneous predators which check the general increase of other insects. They are protected by their ferocious habits, their hardness and by a volatile and offensive fluid (*Pheropsophus*). Their habitat includes every part of the earth's surface, and they are among the most universal of insects. Many thrive in the plains, some in the hills. Cultivated areas harbour many, as do the wastelands and jungles.

The number of species in India is a large one, and the family is one of the most rich in species. A list of the catalogued species of the region may be found in the Journal of the Asiatic Society of Bengal. Vol. LIX (1890), Appendix C. By no means all the species are described and there are large numbers to be added to this list. A total of fifty has been described since Atkinson's catalogue, showing how little attention has been paid to the group during the last two decades. The student may consult Bates' paper on the Ceylon species, collected in five months by Lewis, to realise the magnitude of the group (Ann. Nat. Hist., VI, Vol. 16, pp. 68, 43, 199). It is a noteworthy fact that this family are far more abundant in tropical than in sub-tropical or temperate India, and their place in the plains is to some extent taken in the hills by spiders so far as their predaceous function is concerned. Over 600 Indian species are enumerated by Atkinson. The groups are divided as follows :—

CARABINÆ.	*Omophronini* 4.
	Carabini 14.
	Nebriini 3.
	Enceladini 1.
	Scaritini 76.
HARPALINÆ I.	*Panagæini* 16.
	Siagonini 13.
	Ozænini 2.
	Nomiini 2.
	Bembidiini 19.
	Pogonini 2.
	Pterostichini 65.
	Licinini 6.
	Platynini 45.
HARPALINÆ I.	*Anchonoderini* 2.
	Ctenodactylini 5.
	Odacanthini 11.
	Dryptini 27.
	Lebiini 87.
	Helluonini 12.
	Anthiini 4.
	Ceratocerini 15.
HARPALINÆ II.	*Brachynini* 41.
	Apotomini 2.
	Broscini 4.
	Chlæniini 90.
	Harpalini 38.
PSEUDOMORPHINÆ.	9.

PLATE XVI.—ADEPHAGA.

Fig. 1. Pronyssa nodicollis. (Cicindelidæ).
,, 2. Cicindela withilli. ,,
,, 3. Calosoma indica (Carabidæ).
,, 4. Scarites nanus. ,,
,, 5 Dicranoncus amabilis. ,,
,, 6. Cicindela imperfecta. (Cicindelidæ).
,, 7 ,, aurofasciata. ,,
,, 8. Chlœnius circumdatus. (Carabidæ).
,, 9. Trichisia morio. (Carabidæ).
,, 10. Haliplus angustifrons. (Haliplidæ)
,, 11. Collyris distincta. (Cicindelidæ).
,, 12. Cicindela grammophora. ,,
,, 13. Tetragonoderus sp. (Carabidæ).
,, 14. Eudema angulatum ,,
,, 15. Platyrhopalus denticornis. (Paussidæ).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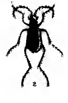
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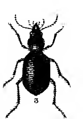
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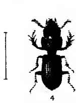
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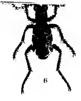
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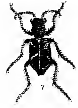
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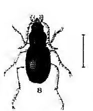
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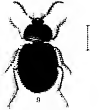
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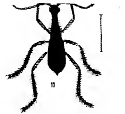
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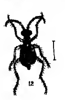
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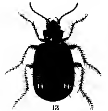
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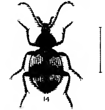
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It is impossible to attempt to discuss the classification and discrimination of our abundant Indian forms, which form one of the largest families. It may be hoped that these insects will soon be dealt with in the Fauna of India.

Carabus includes only a few Indian species and is more abundant in the palæarctic region. *Calosoma* (Plate XVI, Fig. 3), includes the species *Orientale*, Ho.. found in Peshawar to be predaceous on young locusts (*Schistocerca peregrina*). *Ophionea* is a pretty little insect, common in the plains, and with several Indian species. The colouring and facies are distinctive, slender flattened insects marked in brown and red. *Dendrocellus* is another Indian genus extending also to West Africa. *Brachinus* is a widespread genus, usually black, with ferruginous head and prothorax, and greenish elytra. *Lebia* is another large genus, well represented in India; the beetles live chiefly on bark and plants, and are brightly coloured. The genus *Anthia* has a single Indian representative, the large *A.* (Pachymorpha) *sexguttata*, Ho. This insect is one of the most striking beetles of the plains, black, with six large white spots. It is wingless and found wholly on the soil, spending the winter in holes. A few kept in captivity lived for some months, fed daily with from one to two hundred grasshoppers. Eggs were laid but failed to hatch. This is one of the few *Carabids* easily

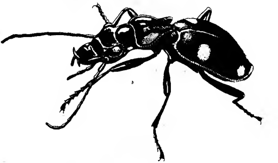


Fig. 151.—ANTHIA SEXGUTTATA, × 1⅓. (F. M. H.)

identifiable, and I have been told that it figures among the folk tales of natives of some parts of India. The *Scaritinæ* have a distinct facies (Plate XVI, Fig. 4), and are further marked by their pedunculate prothorax and enlarged digging legs, similar to those of the *Coprides.* They are black insects, some quite small, others of moderate size, and are, so far as is known, wholly digging insects. Some are diurnal, some nocturnal, and while most are predaceous, some appears to feed on decaying animal matter. *Clivina* is one of the larger Indian genera, with many Indian species.

Collecting.—*Carabids* are sufficiently abundant to be readily found and collected. They must never be put living with other insects but kept apart or killed at once with benzene. In this group, details of the food of the beetles is much wanted; every larva found should be reared, feeding it on living insects; though the beetles are extremely numerous, few larvæ are known and fewer still have been reared. Attempts to rear *Anthia* have failed, though their eggs were obtained and it will probably be more satisfactory to rear from captured larvæ. These should be carefully sought for whenever caterpillars are abundant, as they collect at such spots. Larvæ are best preserved in formalin.

PAUSSIDÆ.

A family of small beetles most readily recognised by the extraordinary form of the antennæ, which are usually very large, as well as by the truncate elytra which usually leave the pygidium exposed. Tarsi five-jointed.

These remarkable beetles are of small size, generally near to one-quarter of an inch long, coloured almost wholly in red-brown and black. The head bears the remarkable antennæ and the somewhat reduced mouth-parts; the former have two, six or ten joints: in many cases there is a small basal joint and a single large leaflike apical joint; in others the expanded part consists of the apical five joints. The prothorax is well developed and of varied form; the elytra are parallel-sided and truncate behind, the pygidium visible in most species. The legs are of varied form, sometimes expanded and leaflike, usually slender and formed for walking.

The life-history of no species is known. These beetles are found at light, have been repeatedly found walking on the soil and are found in ants' nests. It is believed they are all myrmecophilous, living on varying terms of indebtedness in the nests of surface ants. They fly quickly and settle with the wings extremely quickly closed, so that they appear to fall rather than to settle. As in the previous family, these beetles secrete a liquid which is irritant to the human skin.

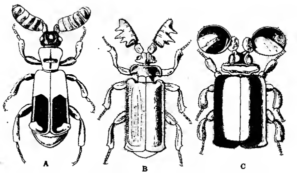


Fig. 152.—A. CERATODERUS OBERTHURI, B. EUPLATYRHOPALUS APLUSTIFER, C. PLATYRHOPALUS MELLYI.
(*After Desneux.*)

Of the known species (Desneux, Genera Insectorum), nearly 300 in number, about one-seventh are Indian, and the fauna is comparatively rich in forms. They are found in the plains as in the hills and probably many plains' forms remain to be discovered.

Platyrhopalus denticornis, Donov. (Plate XVI). is apparently the most common, found at light and walking on the soil. *Merismoderus Bensoni*, Westw., is known from the United Provinces and figured by Westwood (Cab. Oriental Entomology, Plate XLI, Fig. 4); he states that it was found in a "black ants' nest." Many Indian species of this family are figured in Westwood's Arcana Entomologica.

MYRMECOPHILOUS INSECTS.

In a publication, dated 1894, Wassmann enumerates nearly 1,200 insects which live in some degree of association with ants, and over one hundred living in connection with termites. The former are the "Myrmecophilous" insects; they possess a special interest chiefly on account of the fact that a large proportion of them are not inimical to the ants in whose nests they live, but they play an important part in the economy of the nest and are deliberately fed and maintained by ants. The ant community is much like the human community; it has species of insects that it domesticates, feeds, tends and preserves on account of the food it derives from them; there are others which live in harmony with them, are tolerated but are not known to have any value to the ants; there are insects hostile to the ants themselves, but which, nevertheless, maintain themselves in their nests; and there are parasites which live in the bodies of ants.

The same applies to termites but far less is known of them since they are tropical insects and have been far less studied. It is probable that the "termitophilous insects" are as varied and numerous as the myrmecophilous insects and there is here a great field for observation and research in this country.

Comparatively little is known of myrmecophilous insects in India; Wroughton, Rothney and others who investigated Indian ants, found a number of species and Wroughton has also found termitophilous insects; but the number recorded and the observations made covers only a very small part of the ground. We have here endeavoured to condense from Wassmann's Kritisches Verzeichniss not only the groups found elsewhere but the recorded Indian species.

Escherich describes three Termitophilous Thysanura, of the Genera *Assmuthia* and *Platystelea* from India (Zool. Anz., p. 743). *Myrmecophila* among Orthoptera is the sole recorded genus: Wroughton and Aitken record *M. acervorum*, Panz. var *flavocincta*, Wassm. in the nests of *Plagiolepis longipes*, Jerd. This little insect is one of the *Myrmecophilinæ* (Gryllidæ). Wassmann (Zeitsch. Wiss Insecten-biol. 1, p. 334), describes *Myrmecophila prenolepidis* found in Bombay by Assmuth, running with the ants (*Prenolepis longicornis*) which were moving their nest at the beginning of the rains. The same *Myrmecophila* occurs with the same ant in Brazil. Two other species of *Myrmecophila* are known to live with *Pheidole Wroughtoni* and with *Camponotus compressus*. The author states that *Myrmecophila* lives with one ant species in its nymphal instars and with another when full grown.

Among *Neuroptera*, a single Psocid is recorded. Some *Eutermes* live in a friendly manner with species of *Termes* and are thus Termitophilous. In *Hymenoptera*, we have first the ants living in a social way with other ants; thus a small ant may make nests by tunnelling in the solid earth left between the galleries of a much larger kind of ant; or two kinds of ants may share a nest. Wassmann records no instances from this country but our common ant *Myrmecocystus setipes* certainly allows another ant to build between its galleries, and there are probably other instances. Ants are also termitophilous in that they live in termites' nests. Two sphegid wasps, *Rhinopsis constanciæ*, and *R. ruficornis*, Cam., mimic and live where *Sima rufonigra* is common; but the exact relations are doubtful. Elsewhere, Fossorial wasps prey upon ants, carrying them off to stock their cells with. Various Parasitic Hymenoptera destroy ants but none are yet recorded in India. *Lepidoptera* include a very few whose larvæ live in ants' nests (none Indian), and a number which are visited by ants, which have special "honey organs" and which in some cases pupate in the ants' nests. deNiceville remarks that some of these caterpillars will thrive only in association with their particular ants. These are all *Lycænidæ*; the list embraces the following :—

Polyommatus bæticus, L.	visited by	*Camponotus compressus*, F.
	,, ,,	*Prenolepis clandestinus*. Mayr.
	,, ,,	*Tapinoma melanocephalum*, F.
Tarucus theophrastus, F.	,, ,,	*Camponotus compressus*. F.
	,, ,,	*Pheidole latinoda*. Rag.
Gerydus symethus, Cram.	,, ,,	? ?
Rapala schistacea, Ms.	,, ,,	? ?
Chilades laius, Cram.	,, ,,	*Camponotus compressus*. F.
,, *trochilus*, Frey.	,, ,,	*Pheidole quadrispinosa*. Jerd.
Zizera lysimon, Hubn.	,, ,,	*Tapinoma melanocephalum*. F.
Lycænesthes emolus, God.	,, ,,	*Œcophylla smaragdina*. F.
Lampides ælianus, F.	,, ,,	*Camponotus mitis*, Sm.
Catochrysops cnejus, F.	,, ,,	*Camponotus compressus*. F.
,, *pandava*, Horsf.	,, ,,	*Prenolepis longicornis*, Ltr.
,, ,, ,,	,, ,,	*Monomorium speculare*. Mayr.
,, ,, ,,	,, ,,	*Cremastogaster* sp.

Among Diptera, there are less than 20 species recorded, chiefly European, *Microdon* being the best known. A single Indian example among Heteropterous Rhynchota is the Coreid *Dulichius inflatus*, Kby., which Wroughton found to mimic *Polyrhachis spiniger*, Mayr., and to live where this ant is common. Of the *Homoptera*, there are species of *Fulgoridæ* and *Membracidæ* which are visited by ants to get the sweet secretion. Our common species of *Leptocentrus* among the latter and *Pyrilla aberrans*, Wlk., among the former are examples. *Psyllidæ*, *Aphidæ* and *Coccidæ* also afford many examples, ants either simply visiting them to get honeydew, or building shelters over them, or maintaining them in their nests. *Œcophylla smaragdina* commonly sews together the leaves round colonies of Coccids and makes shelters for them; a very large number of our Coccids and Aphids are visited by species of *Camponotus*, *Cremastogaster*, *Cataulacus*, etc., though we are not aware of any detailed information as to the species of ants which visit each. A small number of Poduridæ and Lepismidæ are also recorded as being found as guests in ants' nests. We have left the Coleoptera to the last, as they form the greater number of the recorded species. The following families are enumerated as having more than ten Myrmecophilous or Termitophilous species :—

	Myrmecophilous	Termitophilous.
Staphylinidæ	263	59
Pselaphidæ	113	5
Clavigeridæ	89	0
Paussidæ	169	0
Scydmænidæ	32	0
Silphidæ	35	1
Trichopterygidæ	14	0
Lathridiidæ	30	1
Thorictidæ	40	0
Histeridæ	128	7
Scarabæidæ	17	6

Below is a list of eleven species more or less definitely ascertained to be Myrmecophilous in India ; Wassmann includes many others which, from structural characters, he assumes are myrmecophilous, especially Paussids.

Clavigeridæ	*Claviger Hageni*, Motsch.	East Indies.
	Mastiger abruptus, Motsch.	Calcutta.
Paussidæ	*Merismoderus Bensoni*, Westw.	with black ants, Bengal.
	Paussus Fichteli, Don.	Black ants (? *Pheidole*).
	Paussus soleatus, Wasm.	*Pheidole Wroughtoni*, For.
	Paussus suavis, Wasm.	*Pheidole latinoda*, Rag.
	Paussus Wroughtoni, Wasm.	*Pheidole Wroughtoni*, For.
Colydiidæ	*Paramellon sociale*, Waterh.	In ants' nests.
Scarabæidæ	*Chætopisthes fulvus*, Westw.	In Termites' nests.
	,, *simplicipes*, Reiche.	,, ,, ,,
Pselaphidæ	*Aulacophora* sp.	,, ,, ,,

On the analogy of other countries it is probable that there are abundant myrmecophilous and termitophilous insects in India and we reproduce the list above as a guide to the student for what he may expect to find.

In a later paper (Deutsche Ent. Zeitung, 1899, I, p. 145). Wassmann describes the termitophilous insects found in the nests of the common white ant, *Termes obesus*, Ramb., at Ahmednagar by Father Heim. They are four Staphylinids, *Termitodiscus Heimi*, *Myrmedonia tridens*, *Myrmedonia Heimi*, *Myrmedonia sculpticollis* : and two Aphodiine beetles, *Chætopisthes sulciger* and *Corythroderus gibbiger*. As Myrmecophilous, Wassmann mentions the following species :—

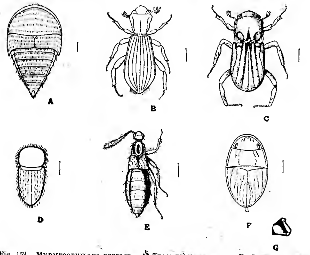


Fig. 153.—MYRMECOPHILOUS BEETLES.—A. TERMITODISCUS HEIMI.—B. CHÆTOPISTHES SULCIGER.—C. CORYTHRODERUS GIBBIGER.—D. THORICTUS HEIMI.—E. WROUGHTONILLA LOBOPELTÆ.—F. COSSYPHODINUS INDICUS.—G. C. INDICUS, ANTENNA FOLDED IN CAVITY.

[*After Wassmann*].

STAPHYLINIDÆ—		
Wroughtonilla lobopeltæ, Wassm.	with	*Lobopelta diminuta*. Sm Nilgiris.
THORICTIDÆ—		
Thorictus Heimi, Wassm.	,,	*Triglyphothrix walshi*. For. Ahmednagar.
LATHRIDIIDÆ—		
Coluocera Beloni, Wassm.	..	*Pheidole sulcaticeps*, Rag. Ahmednagar.
	..	*Holcomyrmex scabriceps*, Mayr. Ahmednagar.

COSSYPHODIDÆ—

Cossyphodinus indicus, Wassm.	with	*Pheidole sulcaticeps*, Rag. Ahmednagar.

TENEBRIONIDÆ—

Dichillus tenellus, Wassm.	,,	*Holcomyrmex scabriceps*, Mayr. Ahmednagar.
Schizillus Rogersi, Wassm.	,,	*Pheidole indica*, Mayr. Mussoorie.
Tetranillus costatus, Wassm.	,,	? ? Ahmednagar.
Stenosis dentipennis, Wassm.	,,	*Cremastogaster* sp. Thana.
,, *Wroughtoni*, Wassm.	,,	*Pheidole latinoda*. North Gujarat.

RHYSODIDÆ.

Head with a slender neck. Antennæ filiform, eleven-jointed. Tarsi five-jointed. Abdomen of six joints, basal three connate. Front tibiæ notched on inner edge.

A small family of two genera; they are elongate, the integument hard and with longitudinal impressed lines; all are coloured black or brown. The few known species have been found under the bark of trees. Lewis revised the family in 1889 (Ann. Nat. Hist. VI, Vol. 2) and listed forty species of *Rhysodes* and *Clinidium*, of which *C. apertum*, Reit., *R. aterrimus*, Chevr., is Indian and *R. taprobanæ*, Fairm., is known from Ceylon. Three species of *Rhysodes* have since been described by Arrow.

DYTISCIDÆ.

Aquatic beetles, the posterior coxæ enlarged, the antennæ filiform. Hind leg formed for swimming. Males with the three basal tarsal joints of foreleg dilated.

These beetles are readily distinguished by the above characters from other aquatic beetles. They are practically aquatic Carabids with the bodily form and appendages modified to suit their mode of life. They include some of the larger beetles and many small forms: the colouring is sombre and probably renders the swimming beetle inconspicuous. The form is oval, the parts very closely united to form one continuous whole with no projecting angles or lines; the head is broad, tightly fitting and only capable of slight movement. The trophi are similar to those of the Carabidæ, the biting carnivorous type.

The elytra cover the abdomen and the wings are large and functional in all species. The anterior legs are set close together, of the usual form except in the males, in which the basal tarsal joints are to a greater or less extent dilated; in some this dilation is so large as to form a conspicuous sucker-like organ and used by the male to securely hold the female. The hind legs are long and formed for swimming, the tarsi compressed and twisted so that the upper edge is outward; they are ciliated on one or both edges. The coxæ are very large and occupy a large part of the ventral surface. The sexes are similar in general appearance and are distinguished by the fore tarsi. These beetles excrete a whitish fluid from the articulation of the head and prothorax on being seized, and also excrete an unpleasant fluid at the anus.

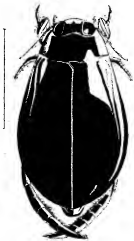


Fig. 154.—CYBISTER CONFUSUS, MALE.

The life-history of no species appears to have been worked out in India and there is no reason to believe it differs from the general type. Eggs are laid in aquatic plants, under water, and hatch into elongated grubs with a large flat head, a long tapering body terminating in two ciliated processes; there are three pairs of long swimming legs. The apex of the abdomen ends in two spiracles which alone are open and functional; the larva comes to the surface tail upwards, the two processes lie flat on the surface film owing to their ciliations and support the grub, which takes in the air supply quickly. The head has a pair of long hollow sickle-shaped mandibles, and it has been shown that when these are in use the mouth is automatically closed; the larva grasps its prey by the mandibles, inserts them and sucks the blood through the hollow mandibles; the larvæ are extraordinarily voracious, and if confined together, attack and destroy one another. They are abundant in freshwater in India, especially if stagnant or nearly so. Pupation takes place in the mud near the water. The adults are aquatic, and carry their air supply under their elytra; they also come up periodically with the apex of the elytra upwards to renew their air supply. They are carnivorous but less voracious than the larvæ and fly at night from pond to pond. Nothing is known of the habits of the Indian species nor of their mode of hibernation, number of broods, etc.

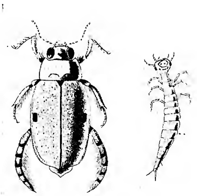


Fig. 155.—Eretes sticticus larva and imago × 3.

Sharp in 1876 experimented with *Dytiscidæ* to find the ratio of the time spent getting air at the surface to that spent under water. He found in *Dytiscus marginalis* a ratio of 1 to 12. *Pelobius* has a ratio of 1 to 375. (Proc. Linn. Soc., 1877.)

The family is a large one, monographed by Sharp (On Aquatic Carnivorous Coleoptera); Regimbart in 1899 revised the Eastern forms (Ann. Soc. Ent. France, 1899, p. 186) listing 140 "Indian" species. Three new ones collected by Maindron were added (loc. cit., 1903, p. 333). The principal genera are arranged as follows:—

I. HYDROPORIDES—

1. *Hydroporini.*—Hydroporus, 4; Hyphoporus, 9; Hyphydrus, 3; Clypeodytes, 6; Bidessus, 6; Yola, 1.
2. *Hydrovatini.*—Hydrovatus, 15.
3. *Methlini.*—Methles indicus, Reg.

II. NOTERIDES—

Hydrocoptus, 4; Canthydrus, 6; Hydrocanthus indicus, We.

III. LACCOPHILIDES—

Laccophilus, 15; Neptosternus, 2.

IV. DYTISCIDES—

1. *Colymbetini.*—Agabus, 10; Platynectes, 3; Lacconectes, 5; Copelatus, 7; Rhantus, 5;
2. *Hydaticini.*—Prodaticus pictus, Shp.; Hydaticus, 8.
3. *Thermonectini.*—Sandracottus, 3.
4. *Eretini.*—Eretes sticticus, Linn.
5. *Cybistini.*—Cybister, 17.

Hyphoporus includes small oval thickset beetles found widespread in wells and tanks. *H. aper*, Shp., appears to be the commonest plains' species. *Copelatus indicus*, Shp., is a small dark insect, abundant in rice fields and found under the bark of trees during the time when the fields are dried up. *Hydaticus Fabricii*, Mch., and *H. vittatus*, Fabr., are the commonest plains species of this genus, medium sized brown insects found in tanks. *Sandracottus Dejeani*, Aub., is widespread and abundant in wells and tanks, a handsome black and brown mottled insect of moderate size.

Eretes (Eunectes) *sticticus*, Linn., is also extremely abundant and common; its larva feeds on *Culex* larvæ. *Cybister* includes the large forms which take the place of the European *Dytiscus*; *Cybister confusus*, Shp., is the large black water beetle with the lateral brown stripe found in fresh water in the plains. *C. tripunctatus*, Ol. var. *asiaticus*, Shp., is smaller, also abundant in rice fields and tanks.

INSECTS AS FOOD.

It is a matter of daily observation that many birds and some mammals find that insects are an excellent food and one may wonder that man has not found this also. But in nothing are the vagaries and caprices of man better shown than in what he will and will not eat, and so a very large supply of food has, and apparently will, daily perish.

Herbivorous insects live in exactly the way a herbivorous mammal such as a sheep does, feeding on the tissues of dry or green plants and transforming them into animal tissues, which differ little from the tissues of a mammal or bird and are but the concentrated nourishment of the living plant; only in many cases they do so far more quickly and are far easier and quicker to rear in large quantities. Why then are they not more eaten? It is pure caprice and we know that many insects are excellent and nourishing food. Unfortunately, there are not the data available to really deal with this subject; in times of scarcity all the world over men have turned to insects and travellers have recorded the insects eaten and the expertness of the little-civilised portion of mankind in finding them; but the subject rests in darkness precisely because the people who practise this habit are not those of whom much is known or whom civilisation reaches; we fear that the spread of civilisation will lead to the total abolition of these interesting practices before we know about them, to the detriment of a later generation which will have to rediscover by experiment which are and which are not, good to eat; unless they adopt the "monkey" test. It is stated in books that what a monkey will eat is good food for man; it is certain that monkeys eat insects with avidity excepting the extremely nauseous ones with warning colouring. Mankind eats many curious things, including oysters, shrimps, whelks and cockles, dried sea slugs (Holothurians), and birds' nests; the most civilised nation is addicted to eating snails, even uncooked; and yet there is an absurd prejudice against insects, not universal, but certainly covering the more civilised portions of mankind. We may doubt if the deterioration in natural instincts that civilisation brings is not revealed in the races that eat so nauseous, deadly and unappetising a thing as an oyster and refuse to consider a nice clean white termite queen or a dish of locusts.

Among the few items of Entomology of this kind, the fact is on record that in Assam, the large bugs of the genus *Aspongopus* are eaten with rice; in Burmah, the red ant (*Œcophylla smaragdina*) is reported to be a delicacy, its pungent flavour relieving the monotony of the daily fare. Locusts are appreciated in many parts of India and it is said that dried locusts form an ingredient of curries even in Calcutta, where a locust swarm is looked on as a providential occurrence. In Burmah, the larvæ of an aquatic beetle are collected and eaten; this is the beetle, *Eretes* (Eunectes) *sticticus*, apparently the commonest species of Dytiscidæ in India. The following observations of this insect in Burmah, are by J. Carey, Esq., Sub-Divisional Officer:—

"An insect called the Twinpo (literally insect found in pits or hollows) is found in Twinywa, a village about 8 miles west of Budalin, situated in a large depression presumably caused by volcanic eruption. The long slender specimens without wings (Fig. 155), are the young insects: the oval shaped ones with wings are the fully developed insects (Fig. 155). They live and thrive in the waters of the lake in the middle of the depression. The waters of this lake are slightly salt and bitter. Among the developed insects, the male can be distinguished from the female by the circular extremities of its front legs. Besides the male is generally smaller than the female. The fully developed insects are seen only after a shower of rain, when the lake is simply agitated by their movements. This is a sign that breeding is going to take place; for soon after the shower the insects creep on to the land and remain embedded in the mud about three or four feet away from the water's edge. Whilst remaining in the mud with their heads slightly exposed, they lay eggs from which the slender needle-shaped insects without wings are found, on the third day. The young insects make for the water as soon as they are formed, and after twenty days reappear still retaining their original slender form, but slightly larger in size. They are then of the same shape and size as the samples. As soon as these young insects appear they make for the land and remain entirely embedded in the earth at a distance of about fifteen feet from the water's edge; the young insect remains hidden in the ground for ten days and after that period it emerges from the ground entirely transformed—instead of the needle-shaped insect devoid of wings, there appears from the ground an oval-shaped insect, possessed of a pair of wings. The insect returns to the lake as soon as it is fully developed.

"The fully developed insects are caught at the water's edge when they are creeping up the land to the mud. The undeveloped slender ones are caught at the edge of the water when they creep up to the land to go through the process of transformation. The insect is eaten in both forms and is considered a delicacy by the Burman."

Termite queens are also eaten in some places in India as in Africa, and we can imagine no more dainty or tempting morsel than such an insect, which is most carefully fed and tended and which presents a most pleasing appearance. In some parts of South India, every boy of an age of 12 to 14 is said to be given a termite queen to eat, after which he runs a distance of two or more miles; having once done this he will be able thereafter to endure fatigue and run well. The large fat grubs of *Oryctes* are also eaten, and probably many other similar insects. It is said to be a common practice among tribes in the wilder parts of India to eat the larvæ and pupæ of the big jungle bee, *Apis dorsata*, found in the combs. So also rearers of wild silk such as tassar (*Antheræa paphia*) are known to regard the pupæ in the cocoon as a delicacy and to eat it when the silk has been reeled off.

These are all the instances we have been able to gather in India: notable cases elsewhere are the egg masses of *Notonecta* in Mexico, and the Grugru worm of the West Indies; we can vouch for the excellence of the latter, which are the larvæ of the Palm Weevil, *Rhynchophorus palmarum:* these are eaten raw or cooked. Eaton records that in Nyassaland, a paste of Mayflies and *Culicidæ* is eaten under the name of "Kungu." The Mayfly is *Cœnis kungu*, Etn. (Monogr. Rec. Ephem., p. 148). A species of *Elmis* (*Parnidæ*) is used as a relish in Peru according to Philippi (Stett. Ent. Zeit., 1864, p. 93).

The reader should consult Wallace's article "On the Insects used as food by the Indians of the Amazon" (Trans. Ent. Soc., London, 1854, p. 241). He mentions five insects belonging to distinct orders which are used as food; the female of an ant called Sauba (*Atta cephalotes*, Latr.) is captured "in basketfuls" when it swarms out of the nests; Wallace remarks "it is rather a singular sight to see for the first time an Indian taking his breakfast in the Sauba season. He opens the basket and as the great winged ants crawl slowly out, he picks them up carefully and transfers them with alternate handfuls of farina (Cassava meal) to his mouth." The worker of a termite (*Termes flavicolle*, Perty) is eaten on account of the mass of muscle in the head and thorax, a Homopterous insect (*Umbonia spinosa*) is eaten roasted, as well as the grub of the Palm Weevil (*Rhynchophorus palmarum*); finally Wallace's last paragraph is worth quoting entire, as it might quite correctly have been written in some parts of India. "The apterous insect which is eaten by the South American Indians, more, I presume, as a delicacy than as an article of food, is a species of *Pediculus* which inhabits the head of that variety of mankind. The method of capturing and devouring this insect is exactly the same as that which everyone has seen adopted by the monkeys at the gardens of the Zoological Society. A couple of Indian belles will often devote a spare half hour to Entomological researches in each other's glossy tresses, every capture being immediately transferred to the mouth of the operator."

The following extract from Cuvier's Natural History refers to the Migratory Locust (*Schistocerca peregrinum*):—

"Some people of Arabia and of some other countries of the East, take them in great quantities, have them dried, ground and made into a sort of bread, when their crops have failed. At Bagdad, they are brought to market and by this means the price of other provisions is said to be considerably lowered. According to report, the locusts have something of the flavour of a pigeon. One man can easily despatch two hundred of them at a meal. The modes of cooking them are various. The Bedouins of Egypt roast them alive upon the coals, and eat them as a great delicacy, having first removed the wings and feet. They also remove, at least in some places, the intestines. The women and children of some parts of Arabia Felix, string them together, and thus sell them. The Arabs roast these insects and steep them in butter, and when they wish to carry their luxury to an extreme, they give them but a single boil in water, and afterwards fry them in butter. The inhabitants of Morocco dry them on the roofs of terraces of their houses and eat them either smoked or broiled or boiled. Other people of Barbary preserve them in pickle. According to Forskæl, there is no great relish in this aliment, and if used to too great a degree, it thickens the blood, and becomes injurious to melancholic temperaments."

That the art of cooking insects is not extinct is shown by the following extract from Harry Roberts' "The Tramp's Handbook" (1903, p. 121). "The larvæ of cockchafers fried with a little salt and pepper are not to be despised, and many of our common caterpillars—including those of the cabbage white butterfly and of the currant moth—may be cooked in the same way."

The cabbage white butterfly is our *Pieris brassicæ*, abundant occasionally in Behar in April; this insect may then prove to be a blessing in disguise.

HALIPLIDÆ.

Posterior coxæ produced behind in a plate partly covering the abdomen. Antennæ bare, ten-jointed.

A small family distinct by the coxæ from *Carabidæ* and *Dytiscidæ*. The antennæ are ten-jointed, inserted near the eyes; the scutellum is absent; the tarsi are narrow as in Carabidæ, and not formed for swimming; in the males the basal three joints in the anterior legs are slightly dilated. These small beetles are found in fresh water, such as ponds and streams; they have a habit of coming out to gather on plants near the water and may sometimes be captured in numbers. No Indian species seems to have been reared and but a very few species are known from India at all. Cardon's collections yielded *Haliplus pulchellus*, Cl., and *H. angustifrons*, Reg. The latter is a small yellow brown insect with black speckles, found also at light. (**Plate XVI**, fig. 10.)

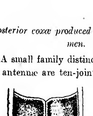


Fig. 156.—HALIPLUS ANGUSTIFRONS. VENTRAL VIEW OF ABDOMEN TO SHOW THE LARGE PLATE-LIKE COXÆ.

GYRINIDÆ.—*Whirligig Beetles.*

Antennæ short, eyes divided, posterior coxæ fixed, posterior legs formed into paddles. Larva aquatic, imago on surface of fresh water.

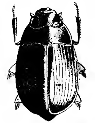


Fig. 157.—DINEUTES INDICUS.

There is little difficulty in recognising members of this family, small shiny beetles which move in incessant activity on the surface of streams and tanks. They are usually of a black colour, the submerged portion pubescent, the rest shiny. The head, prothorax and elytra are closely fitted, the antennæ short and inconspicuous, inserted in a groove in front of the eyes: the head is well developed with the large compound eyes divided, so that one part is in the water, one part in the air. The fore legs are long and slender, the tarsi in the males of some species dilated to form a plate which is set below with little suckers. The posterior legs are modified to serve as paddles, the femur and fibia each dilated into broad plates, the tarsal joints forming a single broad plate. The elytra may be wholly smooth or simply sculptured, or the "submergence line" extends along it, the part below being pubescent, as is the ventral surface of the body. A fœtid liquid is excreted by these beetles, presumably as a protection.

Nothing appears to be on record as regards the life-history of any Indian form: elsewhere the known larvæ are aquatic, living in fresh-water tanks and streams near or at the bottom; this larva has lateral processes on each abdominal segment, functioning as gills, as also four apical abdominal hooks and is active and predaceous on other aquatic

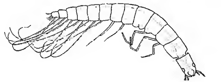


Fig. 158.—GYRINID LARVA, × 4.

insects. The pupa is in a papery cocoon fixed to water plants. The adult lives on the surface of the water, the broad paddles propelling it swiftly along the surface, where it feeds on small insects which it finds near the margin. Numbers may be seen on the margins of fairly still water, continually describing complicated movements together; when alarmed, they plunge below the surface of the water, carrying a bubble of air attached to the hind end. Some species are confined to smooth still water, others to swift mountain streams. All are unable to walk on land and they are found away from water only when flying at night, when they come to light. The family has no economic importance and has been little studied; nothing is known of their hibernation, enemies and the like.

Regimbart's latest monograph (*Genera Insectorum*) enumerates 34 Indian species, in the genera *Dineutes* (4), *Aulonogyrus* (1), *Gyrinus* (2), *Orectocheilus* (27). *Orectocheilus gangeticus*, Reg., is the common plains species, a medium sized black species found abundantly at the margin of rivers. *Dineutes indicus*, Aube., is a larger insect found on streams and stagnant water both in the plains and in the hills.

POLYMORPHA.

If we omit the large distinct, series of beetles the *Lamellicornia*, *Adephaga*, *Phytophaga*, *Rhynchophora* and *Heteromera*, there remains a great assemblage of beetles, many of which fall into well marked families, but a proportion of which are extremely difficult to unite into natural families. Especially is this the case with the numerous forms which live in decaying wood, under the bark of trees, or in mushrooms; these beetles are imperfectly known, their structural characters are very varied and no simple and accurate method of classing them has yet been arrived at, largely through the fact that but few are known. This, while true of these insects as a whole, is still more the case with the Indian forms, of which scarcely anything is known. Nominally these beetles fall into two series, those with antennæ distinctly clavate, those with antennæ distinctly serrate; but many which have other structural affinities with one series have not clubbed or serrate antennæ: their tarsal characters vary in even what are regarded as the limits of a family or sub-family: and actually many families are characterised by such a number of characters relating to the trophi, antennæ, coxæ, tarsi, ventral abdominal segments and the like that the diagnosis to be of any use must be extremely full and detailed, occupying far more space than is available here. While we have given a brief diagnosis of the families we know to be represented in India, we are not sanguine that the student will place every beetle in its family by consulting these diagnoses. Some of the larger families are distinct enough; for the rest if the characters obviously agree with any diagnosis, the beetle can probably be placed provisionally in that family; if, as in many cases, the student abandons the task as hopeless, there is no remedy but to consult some work in which the diagnoses are given in fuller detail.

Actually a large majority of the smaller obscurer Polymorphous beetles found will undoubtedly be new and while their characters may agree with known genera, they are likely not to and we must anticipate the formation of new groups of beetles when our fauna is better studied. Finally in this heterogeneous group above all, a good reference collection is essential as the actual interpretation of the characters and their just appreciation is no easy matter and is only to be gained by practice and experience. The majority of the following families can usually be distinguished, so far as known Indian forms are concerned :—

Hydrophilidæ.—Antennæ of three parts, fitting under head; a sternal spine often. Part aquatic.

Pselaphidæ.—Tarsi three-jointed. Elytra truncate. Abdomen of 7 or less segments, not mobile.

Staphylinidæ.—Tarsi three-jointed. Elytra truncate. Abdomen 7 or 8 mobile ventral segments.

Sphæriidæ.—Tarsi three-jointed. Antennæ clubbed. Three ventral segments.

Trichopterygidæ.—Tarsi three-jointed. Wings fringed with hairs. Very minute beetles.

Corylophidæ.—Tarsi four-jointed, first joint very small. Wings hair-fringed. Very small.

Scaphidiidæ.—Tarsi five-jointed. Antennæ with the five apical joints broadened.

Histeridæ.—Tarsi five-jointed. Elytra truncate. Short clubbed antennæ. Hard compact beetles.

Phalacridæ.—Tarsi five-jointed, fourth very small. Posterior coxæ contiguous.

Nitidulidæ.—Tarsi five-jointed, fourth very small. Posterior coxæ not contiguous. Elytra often abbreviate or truncate.

Trogositidæ.—Tarsi five-jointed, first very small. Antennæ with apical joints broadened on one side only.

Erotylidæ.—Tarsi five-jointed, basal three broadened, fourth small, fifth long (c.f. *Chrysomelidæ*). Antennæ clubbed.

Coccinellidæ.—Tarsi four-jointed, third very small. Antennæ not clubbed.

Endomychidæ.—Tarsi four-jointed, third very small. Antennæ clubbed.

Lathridiidæ.—Tarsi three-jointed. Five visible ventral segments (c.f. Staphylinids).

Dermestidæ.—Tarsi five-jointed. Antennæ short, clubbed, and hidden in a groove in prothorax.

Byrrhidæ.—Tarsi five-jointed; small, hard compact beetles, the femora fitting into the coxæ.

Heteroceridæ.—Tarsi four-jointed. Antennæ with seven apical joints broadened. Aquatic, in mud.

Parnidæ.—Tarsi five-jointed, fifth long. Aquatic.

Bostrichidæ.—Usually cylindrical, hard, and rugose. Tarsi five-jointed, basal joint small. Antennæ often serrate.

Ptinidæ.—Usually cylindrical, hard, and rugose. Tarsi five-jointed, basal joint not small. Antennæ often serrate.

Malacodermidæ.—Soft beetles, with 6, 7 or 8 ventral segments, antennæ pectinate or serrate.

Elateridæ.—Antennæ pectinate or serrate usually. Prosternal process. Hind angles of prothorax prolonged backwards, prothorax movable.

Buprestidæ.—Antennæ serrate. Prosternal process, prothorax fixed. Tarsi five-jointed, basal four with pads.

HYDROPHILIDÆ.

The antennæ with a long basal joint, the remainder forming a club, the apical joints broadened, fitting below the head. Tarsi five-jointed, basal joint often small.

This family is recognisable by the antennæ, which are of the form figured (fig. 137), the broader apical joints being pubescent. They consist of a basal joint, a club of three to five joints and one to three small intermediate joints. They often bear a general resemblance to *Dytiscidæ*, the aquatic forms having a similar oval form but being less compact. The terrestrial forms are more globose and rounded, but with the general facies of the family. They are black or dull-coloured insects, generally less than half an inch long. The head, prothorax and elytra fit closely, and are usually smooth and shining. In the aquatic species, the hind

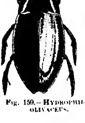


Fig. 159.—HYDROPHILUS OLIVACEUS.

legs are slightly flattened and set with hairs, so as to render them capable of acting as paddles.

The life-history of no Indian species has been worked out and nothing appears to be on record. The life-history of aquatic species elsewhere is known and the student should consult Miall's "Aquatic Insects." The eggs are laid in a case formed of filaments excreted from the silk tubes at the anus of the female beetle; this case is hollow and has a projecting process like a mast; it is fixed to aquatic plants at the surface of the water. The young are similar in general form to those of the *Dytiscids* (the tarsus with one claw) and also predaceous; air is obtained by bringing the large spiracles at the hind end of the body to the surface. Pupation takes place in the mud. The beetles swim actively and obtain air by coming to the surface head up, the air being contained on the lower surface of the body and communicating with the cavity in which the antenna lies; when the head comes up, the air supply is in contact with the atmosphere through this channel and is renewed. The beetles are principally vegetarian and not predaceous. Only a part are aquatic, some being found in mud, near streams and ponds, under the bark of trees and in dung.

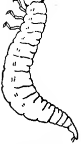


Fig. 160.—HYDROPHILUS PICEUS LARVA. (*After Chapuis.*)

The family is a moderately large one, divided into five sub-families as follows :—

I. Basal joint of posterior tarsi short, second long.
    (*a*) Posterior tarsi formed for swimming. A sternal process present .. *Hydrophilinæ.*
    (*aa*) Posterior tarsi normal. No sternal process .. .. .. *Hydrobiinæ.*
II. Four basal joints of posterior tarsi short and equal .. .. .. *Spercheinæ.*

III. First basal joint of posterior tarsi very short, rest short and equal .. .. *Helophorinæ.*

IV. First basal joint of posterior tarsi elongate .. .. *Sphæridiinæ.*

Régimbart's papers (Ann. Soc. Ent., France 1903, p. 52 and p. 331), should be consulted for descriptions. The *Hydrophilinæ* are aquatic and eighteen Indian species were listed by Atkinson, 7 having been since described. *Hydrophilus* includes among several species the common species *H. olivaceus*, Fabr. ; this may be found in tanks and should be handled cautiously on account of the large spine projecting from the sternum beyond the hind coxæ. The European *H. piceus*, Linn., is not an Indian species properly, though captured in the Himalayas. *Hydrous* has the sternal spine shorter and a double keel. The larger forms of these two genera are revised by Régimbart under the same *Stethoxus* and *Dibelocelus* : (Ann. Soc. Ent., France, 1901, p. 188). Out of forty species the seven following are given as "Indian:"

H. senegalensis, Perch. ; *H. olivaceus*. Fabr. ; *H. cashmirensis*, Redt. ; *H. rufoinctus*, Bedel. ; *H. indicus*, Bedel. ; *H. acuminatus*, Mots. ; *H. piceus*, Linn.

These larger forms can be identified from this paper, but the student must remember that the smaller forms are still listed under *Hydrophilus*.

Hydrobiinæ.—These include the smaller aquatic beetles which are found in water, but which crawl along the bottom near the edge rather than swim freely. The females lay eggs in cases fixed to plants or which they carry with them. The larvæ are predaceous.

Philhydrus nigriceps, Westw., is common and widespread. *Berosus. decrescens*. Wlk., is a small species found in tanks. *Berosus indicus* Motsch., *Brachygaster indica*, Muls., and *B. metallescens*, Muls., are recorded. *Globaria leachi*, Latr.. represents this genus.

Spercheinæ.—So far as known, these are aquatic, their larvæ predaceous in stagnant water. *Spercheus* is the common genus but none are known in India.

Helophorinæ.—Not strictly aquatic but living in mud : *Hydrosus* ***binodosus***, Motsch., *H. opacus*, Motsch., and *H. violaceomicans*, Motsch. are the recorded representatives of this group.

Sphæridiinæ.—Terrestrial beetles, except *Cyclonotum*, which is aquatic. *C. orbiculare*, Fabr., occurs in India, as also Europe *C. capense*, Deg., and *C. abdominale*, Fabr., also occur.

Sphæridium 5 *maculatum*, Fabr., is common in the plains, a small black and brown species. *Cercyon* is well represented in Ceylon and by five Indian species. *Pachysternum apiatum*, Motsch, also occurs.

SILPHIDÆ.

Antennæ usually clubbed. Abdomen of five or six segments, free. Eyes finely granulated. Tarsi of four or five joints. Anterior coxæ conical and contiguous.

A larger family of beetles of varied form, usually of small size. The elytra are sometimes truncate, exposing the apex of the abdomen, but usually cover the whole abdomen. The posterior coxæ are contiguous. The known larvæ are flat, tapering to the hind end, with a pair of anal cerci and a distinct labrum; no Indian larvæ are known. The beetles have, in general, similar habits to the *Stophylinids* but a few (*Necrophorus*, etc.) of the larger are the so-called Sexton or Burying Beetles, which by removing the soil below small animal's corpses bury them, and then feed and breed in the decomposing body. The latter are not known in Tropical India. One species has been sent in as being destructive to dry cured fish in Sylhet, with *Necrobia ruficollis*, Fabr. (*Cleridæ*).

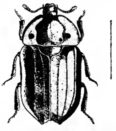


Fig. 161.—SILPHA TETRASPILOTA.

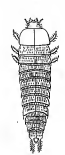


Fig. 162.—NECRODES LITTORALIS; LARVA. (*After Chapuis.*)

Necrophorus is represented by *N. nepalensis*, Ho., in the Himalayas, and *N. encoustus*, Fairm., from Simla. *Necrodes osculans*, Nig., is Indian, as are 7 species of *Silpha*, of which *S. tetraspilota*, Fabr. (fig. 161), is not uncommon in the plains. *Nodynus nitidus*, Ho., *Apatetica lebioides*, Ho., *Choleva vestita*, Murr. and *Aclypea sculpturata*, Grouv., are the remaining species. Portevin has recently described eleven new species (and four new genera) from the collection made by Mons. Harmand at Darjeeling. (Ann. Soc. Ent., France, 1904, 1905.)

Apatetica lebioides, Westw., is described and figured from the Himalayas (Cab. Or. Entom. Pl. XLI, fig. 9). It is in appearance a Carabid, and with its ally *Pteroloma* was formerly placed in the *Carabidæ*.

SCYDMÆNIDÆ.

Elytra covering the abdomen, which is six-jointed below. Eyes coarsely granulated. Tarsi five-jointed.

This family includes small, usually winged beetles, of brown colour, covered with erect hairs, and in structure closely allied to the last family from which they differ in the eyes and the more conical form. They are found in ants' nests, in decaying vegetation, under bark, etc., and are probably largely predaceous, though there are few actual records of the food. The 14 known Indian species belong to the genera *Scydmænus* (9), *Syndicus* (1) and *Eumicrus* (5); they are of no economic importance whatever, are only seldom found and are never abundant.

PSELAPHIDÆ.

Elytra short; abdomen of five (rarely six) ventral segments: maxillary palpi large and tarsi three-jointed.

An extensive family of small beetles, imperfectly known. It differs from the next chiefly in the abdomen. The colours are sombre, brown predominating. The beetles are known to be predaceous on small forms of life, such as mites and in some cases (*Claviger*) are myrmecophilous: the family is widely spread but little known. Two sub-families are recognised, ***Pselaphides*** with many genera, *Clavigerides* with few. The family are of no importance economically and our knowledge of Indian forms must remain small until Indian beetles are far more carefully collected.

Raffray has catalogued the known species (Ann. Soc. Ent. France. 1903-1904, and Genera Insectorum, 1907). He lists 53 *Pselaphines* and one *Clavigerine* as occurring "in India," the majority having been found in Ceylon and Burma. (No less than sixty additional Indian species are characterised by Raffray as "species mentioned by Motschoulsky but not "described;" these are included in Atkinson's catalogue but are not valid species). Raffray has since described nine species from the Nilgiris and Belgaum (Ann. Soc. Ent. Belge, 52, 205). We have found one species in an ant's nest (*Myrmecocystus setipes*) in Behar; the only known Indian *Clavigerine* beetle is *Mastiger abruptus*, Mots., described as from Calcutta.

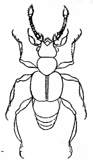


Fig. 163.—DINOPTERUS CEYLONICUS. (*After Raffray.*)

STAPHYLINIDÆ.—*Rove Beetles.*

The elytra truncate and covering only the base of the abdomen, which is long with ten dorsal and at least seven visible ventral segments. Tarsi variable, three, four or five-jointed.

In this family are small beetles, rarely exceeding one-quarter of an inch in length, usually recognisable in the field from all but *Nitidulidæ*. The colours are usually sombre, browns and blacks as in most surface insects, while a few which live openly on plants exhibit a brighter colouring (*e.g.*, *Pæderus*).

The antennæ are of moderate length, simple, the head large with short biting trophi; the prothorax is distinct, the sides of the body more or less parallel and the abdomen long, tapering and flexible. The large folded wings are concealed under the small truncate elytra, which meet in a straight line in the middle over the base of the abdomen.

The legs are short, formed for rapid running; the tarsi are often three-jointed, in some four or five-jointed throughout, and in a number the fore tarsi are four-jointed, the posterior tarsi with five pairs of joints. The integument is less thickened and hardened than in most beetles, the abdominal segments are mobile and readily turn up, suggesting the

Forficulidæ which these beetles much resemble at first sight. The tip of the abdomen is curled upwards over the dorsum to assist in packing away the wings under the small elytra after flight.

Nothing is on record as to the life-history of Indian species. In general the larvæ resemble the imagines in general form, with large

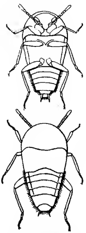


Fig. 164.—LEUCOCRASPEDUM PULCHELLUM. (*From Kraatz.*)

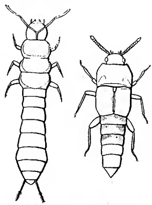


Fig. 165.—LEPTOCHIRUS MANDIBULARIS LARVA (LEFT): HOLOSUS TACHINIFORMIS. (*From Kraatz.*)

heads, shorter antennæ and prominent mandibles: the body tapers and is provided with two dorsal processes and a short anal tube. The latter assists in locomotion much as the anal prolegs of a caterpillar. The larval habits are probably similar to those of the imagines, though the larvæ live a more retired life and are not readily found. They form part of that great fauna which lives on the surface of the soil in concealment, and of whose habits we are profoundly ignorant. The study of the habits of this immense fauna is far less advanced than that, for instance, of the plant feeding species and there is here an immense field for research.

The beetles have a variety of habits, feeding on decaying vegetation, decaying animal matter, small insects and probably other small forms of life. A few frequent plants for the purpose of obtaining plant sap or pollen. Some live upon fungi and none are known to be feeders on living plant tissues or directly injurious. They are, on the whole, scavengers, with a tendency to being predatory. Exceptional species have been found in ant's nests, and there are probably a considerable number of these Myrmecophilous forms in India. The larger forms can exsert two vesicles from the hind end, which set free a noisome fluid.

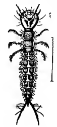


Fig. 166.—STAPHYLINUS CHLOROPTERUS. LARVA. (*After Perris*).

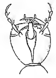


Fig. 167.—HEAD OF LARVA OF STAPHYLINUS CHLOROPTERUS. (*After Perris*).

The family is a very large one, not much studied. Atkinson lists 286 Indian species and over 60 have been since described. The papers of Motschulsky and Kraatz prior to the Munich Catalogue, and those of Fauvel and Eppelsheim more recently, contain the descriptions of most of our species. Wassman has described the Myrmecophilous forms. We figure the large *Staphylinus semipurpureus*, a giant among the species of this family found in the moister parts of India.

The only common genus likely to attract attention in the plains is *Pœderus* which includes several small species coloured in dull red and blue, which are common on plants and run actively about on crops. They have been seen to feed on pollen but have not been found to be injurious and at times they are certainly predaceous on small insects; in one instance they fed upon the egg masses of *Caradrina exigua* and destroyed large numbers.

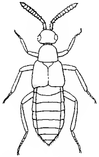


Fig. 168.—MYRMEDONIA LÆVIGATA KR. (*From Kraatz*).

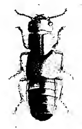


Fig. 169.—STAPHYLINUS SEMIPURPUREUS.

Collecting. Staphylinids are found most readily by searching in damp decaying vegetation, in rotting fruits, under stones, at small carcases: many come to light and a few are found on plants or running on the surface of the soil. Moisture seems to be a necessary condition for their well being. None appear to have been reared in India. For the collection all but the largest forms should be very carefully gummed on card, the abdomen being carefully drawn out as it is apt in drying to shrink. It is to be hoped that more attention will be paid to the habits of these small and insignificant insects, which may be found to play an important role. Careful observation and rearing is required coupled with thorough and exhaustive collecting; results of great interest and possibly of economic value will reward the patient investigator.

TRICHOPTERYGIDÆ.

Antennæ with a three jointed club. Elytra abbreviated or complete Wings fringed with hair.

The smallest known beetles are here included, measuring from 1/25 to 1/75 of an inch in length. A characteristic feature is to be found in the wings, which consist of a narrow stalk bearing a blade set with long hairs on each side. These wings fold under the elytra. These little beetles are found amongst decaying vegetable matter and under the bark of trees; most are shining brown and are apt to be passed by on account of their small size. They are often found in numbers together. No Indian species appear to have been reared. The larvæ of the known species are stated to be active and predaceous on small insects. *Ptenidium macrocephalum*, Nietn., with several Ceylon species is recorded.

CORYLOPHIDÆ.

Very small beetles, the antennæ of peculiar form, six free abdominal segments, tarsi apparently three-jointed.

Like the *Trichopterygidæ*, many of these small beetles have fringed wings. Eleven species are known from Ceylon and one from Burmah.

SCAPHIDIIDÆ.

Abdomen with six or seven visible ventral segments, the basal ventral segment large. Tarsi of five joints. Elytra truncate, with two longitudinal striæ, with raised points between. Antennæ with the five apical joints broadened.

These small beetles are found in mushrooms and beneath stones. They are recognisable only from careful examination of the whole characters. The antennæ are but slightly clubbed. The truncate elytra expose only the apex of the abdomen. The wings are well developed and the beetles are active. The apex of the abdomen as seen from below is conical and rather long. Only a few genera are known and these are widespread. *Scaphidium conjunctum* Motsch., *S. lunatum*, Motsch. and *S. cyanellum*, Obart. are recorded as Indian with several Ceylon species.

HISTERIDÆ.

Elytra usually truncate. Integument hard, body compact. Antennæ of one long basal joint, a number of small joints(7), and an apical club of three joints.

These small hard beetles are generally recognisable at sight from their general build and the above characters. Nearly all are black or dark blue, a few variegated with brown or yellow. The colouring is that common to so many beetles which live in concealment and on the soil. The body is thickset and short, sometimes very markedly flattened; the integument is peculiarly hard and the whole structure compact and neat. The upper surface is commonly bare and shining, the elytra smooth or with indented lines between which are punctures, whose form is sufficiently constant to serve in species discrimination. The head is small and retracted, the antennæ short, hidden in repose, the biting mouth-parts well developed, the mandibles often long and conspicuous. The prothorax is large, receiving the retracted head and broadly united to the abdomen. The elytra are truncate behind and do not cover the pygidium. The legs are short, folding under the body in repose, the tibiæ broadened and fitted for digging.

No species appear to have been reared in India, and little is known of the details of the metamorphosis of the family at all. So far as known the larvæ are active and predaceous. They have anal cerci, the labrum and ocelli are wanting and they live wholly in concealment. The adults are found under bark or stones, among roots, in dung, in carcasses, in dead insects; some (*Teretrius*, *Teretriosoma*), are known to be predaceous in the bores of Bostrichid beetles, others on insects found in the spots they frequent. A species of *Hister* is stated to feed on *Agrotis* larvæ in Corsica (Ann. Soc. Ent., France, 1864, p. 304). How far they are scavengers themselves and how far predaceous upon insects is uncertain; none are in any degree injurious and it may be found that as a whole they are beneficial. They are rarely found in the open by day and are principally nocturnal in habit.

Marseul's Catalogue (Ann. Soc. Ent., France, 1862), enumerated 1010 species of which 51 were Indian. Many additions have been made since that time and Lewis has published descriptions of many new species in the "Annals of Natural History." In his recent Catalogue, Lewis enumerates 95 as occurring in India and Assam, apart from Ceylon and Burmah. These are *Niponius* (3), *Hololepta* (5), *Trypeticus* (1), *Teretriosoma* (4), *Teretrius* (1), *Plæsius* (1), *Apobletes* (2), *Platylister* (3), *Platysoma* (6), *Eblisia* (1), *Pachylister* (5), *Hister* (23), *Epierus* (1), *Pachylomalus* (1), *Cypturus* (1), *Phelister* (1), *Anaglymma*

(1), *Notodoma* (1), *Sitalia* (1), *Epiechinus* (1), *Abraeus* (3), *Halacritus* (1), *Saprinus* (14), *Gnathoncus* (1).

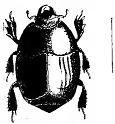


Fig. 170.—PACHYLISTER BENGALENSIS.

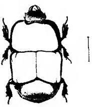


Fig. 171.—HOLOLEPTA INDICA.

The family is divided into a number of sub-families which need not concern us. *Hololepta* and *Platysoma* include flattened black species found under the bark of trees, where they prey upon bark-feeding insects. In *Hololepta elongata*, Er. this flattening is carried to an extraordinary extent, the beetle being scarcely thicker than a visiting card. *Hister* is the abundant genus with many species; *H. javanus*, Payk. is common in cow dung in the plains as is also *H. bipustulatus*, Fabr. var *immaculatus*. *Saprinus interruptus*, Payk. represents this genus commonly, the beetle being black with a large yellow blotch on each elytron.

PHALACRIDÆ.

Antennæ with a distinct three-jointed club. Tarsi five-jointed, fourth joint small. Abdomen five visible ventral segments; front coxæ globular, hind coxæ contiguous.

A family closely resembling the next, but distinct in the structure of the coxæ. There are but few genera and the Indian species appear to be little known. *Olibrus* (5 spp.), *Augasmus* (3 spp.), and *Phalacrus* (5 spp.) are the recorded genera.

NITIDULIDÆ.

Antennæ with a club of three joints. Tarsi five-jointed, fourth joint smallest; abdomen with five free ventral segments. Anterior coxæ transverse; elytra often truncate.

Small beetles, of brown or black colour, finely pubescent above, which have a general resemblance to *Staphylinidæ* as many have the elytra truncate, leaving the apical half of the abdomen exposed. The structural characters above separate them from other beetles and they can often be recognised in the field.

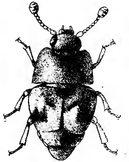


Fig. 172.—CARPOPHILUS HEMIPTERUS, × 20.

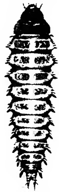


Fig. 173.—LARVA OF AMPHICROSSUS DIS-COLOR.

The known larvæ live principally in flowers, feeding, for instance, on the anthers, but also in dead animals and in decaying fruits. *Carpophilus hemipterus*, lives in dried fruits and similar food articles, feeding on this or possibly on moulds or fungi growing on this material. It has been reared from larvæ found under the sheathing leaves of bamboos. The beetles are found in a variety of situations; many come to fallen fruits or to damaged fruits or plants to obtain the sap. Others are found in flowers, particularly cotton flowers, in injured bolls, in the bores of insects, at cut canes, in almost any situation where they can obtain the sap of plants. Others are found at decaying animal matter, or in hiding at the roots of plants, under leaves, etc. They have also been found breeding in the decaying fibres of the fruits of a palmyra palm and are common among decaying vegetable matter breeding freely in decaying mangoes, for instance. Others are found killed by the sticky leaves of the tobacco plant.

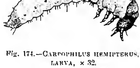


Fig. 174.—CARPOPHILUS HEMIPTERUS, LARVA, × 32.

Murray summarises the habits of the group as follows :—

"The chief function of this family is that of scavengers. Their main business is to clear off decaying substances from the face of the earth, especially those minute and neglected portions which have escaped the attention of other scavengers whose operations are conducted on a larger scale. We may characterize them in one point of view as retail scavengers. They are so to speak users-up of waste materials. After the beast of prey has satisfied his hunger on the animal he has slain, after the hyana and the vulture have gorged themselves on its carrion, after the fly with its army of maggots has consumed the soft parts, after the burying beetles and the Silphidæ have borne their part in the clearing away and when nought but the bones remain, then come the *Nitidulariæ* to go over what they have left, to gnaw off every fragment of ligament or tendon and to leave the bones as nearly in the state of phosphate of lime as external treatment can. In another point of view, however, their employment is wholesale and wide enough. They conduct their operations all over the world, their branches extend into the most remote district; the materials with which they have to do, although mere waste, have no other limit to their variety or their number than the organized substances found on the surface of the globe. As in all great establishments, too, the principle of division of labour is carried to a great extent. Each different kind of substance has a different member of the firm told off to take charge of it. One species confines itself to rotten oranges, another to bones, a third to putrid fungi, a fourth to decaying figs. Decaying wood, decaying bark, decaying flowers, decaying leaves, all furnish distinct employment to different species. They are not all scavengers, however. Many pass their lives in flowers; others feed upon fresh victuals: and Mr. Frederick Smith of the British Museum has, whilst I write, brought to my notice a species of *Brachypeplus* (*B. auritus*) which he has received from Australia, in a wild bee's nest, where it feeds, both in the larva and perfect state on the wax and honey." (Trans. Linn. Soc. Lond., XXIV, pp. 211-414 1864.)

Though of no economic importance, they are common insects and will be readily observed on crop plants under circumstances that would, in the absence of careful observation, give rise to the suggestion that they were themselves the originators of damage, whereas they are essentially the followers of decay.

Murray monographed part of the family in 1864. (Trans. Linn. Soc., XXIV), while Reitter completed the work in 1873 (Verh. Ver. Brunn., XII, pp. 5-194). Many species have been added since by M. Grouvelle. including Father Cardon's species (Ann. Soc. Ent. Belge, 1891. 1892). and Harmand's Darjeeling species (Ann. Soc. Ent. France, 1903, p. 108). A total of over 100 are known from India inclusive of Ceylon. *Carpophilus foveicollis*, Mur. and C. *hemipterus*, L.. are found under the sheathing leaves of bamboos where their larvæ live and the latter, with other species, breeds freely in dried fruits in stores and godowns. *C. dimidiatus*, F. var *mutilatus*, Er., is the common small brown species found in borer holes in canes, in cotton flowers, etc., in the plains. It has been reared from larvæ found in bores of *Chilo simplex* in juar, the larvæ feeding in the decomposing tissues. They pupated in the soil and remained two months as pupæ during the cold weather. *Amphicrossus discolor*, Er.. is a rounder deep brown insect, which has been bred from larvæ found under the bark of Semul (*Bombax malabaricum*).

COSSYPHODIDÆ.

A small family of beetles, separated by Wassman from the foregoing and following families to receive certain Myrmecophilous insects.

Cossyphodinus indicus, Wassman, lives with *Pheidole sulcaticeps*, Rog.. and is the sole recorded Indian species. (Fig. 153).

Colydiidæ.

Antennæ clubbed or dilated towards the apex. Tarsi four-jointed; five visible ventral segments.

These are small beetles of varied form found under bark in decaying trees or in fungi. They are not common and but few species are known from India. *Tarphiosoma indicum*, Wal.. is described from Coimbatore. *Dastarcus* and *Colobicus* are also represented. *Botrideres* is, in Europe known to be predaceous on the larvæ of the *Bostrichid* beetle. *Sinoxylon*, which bores in wood, and Stebbing records the same in India. A total of 17 species are recorded, *Dastarcus indicus*, Fairm., being common under the bark of trees in the plains.

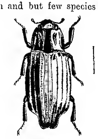


Fig. 175.—Dastarcus indicus.

Lathridiidæ.

Tarsi three-jointed; antennæ with a club formed of one, two or three joints. Ventral abdominal segments five or six, free, the first longest.

Small beetles rarely more than one-tenth of an inch long, found in ants' nests and in decaying vegetable matter, where it is supposed they eat fungi. None appear to have been reared in India. Wassman writes about *Coluocera maderæ*, Wall. and *C. Beloni*, Wasm. Zeits. Wiss. Insecten Biol. 1, p. 384) which live with *Prenolepis longicornis* and *Pheidole* spp. in India. Assmuth observed the former to move with the ants along their runs when shifting nests and Wassman comments on the fact that *C. Maderæ*, like *Myrmecophila prenolepidis*, is found in the nests of this ant in South America as in India, the beetle and cricket having apparently been carried by shipping with the ant.

Eighteen species are recorded in Genera Insectorum as Indian: *Coluocera* (1), *Holoparamecus* (6), *Lathridius* (1), *Ericmus* (1), *Corticaria* (3), *Melanophthalma* (5), *Migneauxia* (1).

TROGOSITIDÆ (TEMNOCHILIDÆ, OSTOMIDÆ).

Tarsi with four apparent, but five actual (the first small), joints. Antennæ with terminal segments dilated at one side.

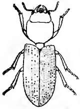


Fig. 176.—TROGOSITA MAURITANICA, × 3.

These beetles may be recognised with care, though superficially they closely resemble those of other families. They are small dark coloured beetles, with short antennæ, a well developed prothorax, the elytra closely fitting over the abdomen and short running legs and are predaceous in their habits. The species are in general found under the bark of trees and in decaying woody matter. *Tenebroides* (Trogosita) *mauritanica*, Linn., is a cosmopolitan insect of which much is written but little known. It is commonly found in stored grains such as wheat, etc., and in almonds and similar seeds, but is generally accounted as a predaceous insect, really useful since it feeds on other insects that feed on the wheat: against this must be put the fact that it has been reared in India more than once from almonds and rice in which no other insect was found; it is probable that, in view

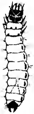


Fig. 177.—TROGOSITA MAURITANICA LARVA, × 3.

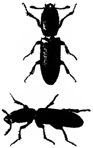


Fig. 178.—ALINDRIA PARALLELA, × 1½.

of all the evidence, the larva is grain-eating, the beetle predaceous, that it was once a grain-eating insect, became predaceous, but still can feed on grain if insects are not available. A. M. Lea records both larva and imago as feeding on caterpillars in Tasmania (1908). The larva causes a peculiar form of injury to wheat seed, eating out the embryo only and leaving the remainder of the grain intact. It is worth noting that it is found living in the open, the larva feeding on larvæ that live under the bark of the oak and chestnut trees in Europe. *Alindria parallela*, Lev., is a larger black insect caught at light during the rains and *Lardites chevrolati*, Reitt., is to be found under the bark of trees.

A. Leveillee has catalogued the family (Ann. Soc. Ent., France, 1900, p. 1). He gives 17 species as found in the Indian region including *Alindria* (3), *Melambia* (4), *Temnochila* (1), *Asava* (1), *Tenebroides* (1), *Acrops* (3), *Gryncharina* (1), *Ancyrona* (3) .

MONOTOMIDÆ.

Two Darjeeling insects are recorded, *Europs indica*, Grouv. and *Europs harmandi*, Grouv. (Ann. Soc. Ent., France, LXXII, p. 123).

CUCUJIDÆ.

Usually small brown flattened beetles, tarsi apparently four-jointed, the first joint often small. Antennæ long, with a small club (often absent).

These little beetles do not readily come into a general definition and are not easily recognisable. The family as a whole are found under tree bark, in decaying wood and attacking stored produce. Several species are found feeding upon grain and stored produce in India, and others have been recorded in Indian Museum Notes. The most noted is *Silvanus surinamensis*, Fabr., whose larva lives in dried fruit, flour, dried mohwa (the calyx of *Bassia latifolia*) and similar vegetable matter. The complete life-history occupies about 7 weeks; the eggs are laid in the food, the larvæ feed inside or between two pieces and pupate in a chamber closed in with bitten pieces of their food. This insect causes considerable annual loss in India, attacking Mohwa, for instance, during the rainy weather and breeding in it steadily till much is lost. *Lœmophlœus pusillus*, F., is a brown beetle which has been reared from larvæ in dried fruit and in ship's biscuit in Calcutta. *Lœmotmetus ferrugineus*, Gerst., was recorded as feeding upon cut cane and probably habitually feeds upon sap. *L. insignis*, Grouv., was found in the wood of a tree bored by *Sinoxylon* and is probably equally harmless. *Hectarthrum heros*, F. (*brevifossum*, Newm.) is a larger black beetle, found under tree bark and in wood tunnelled by borers. About twenty species are recorded as Indian, and many remain to be recorded when they are more collected.

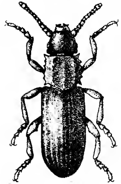


Fig. 179.—SILVANUS SURINAMENSIS, × 20.

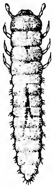


Fig. 180.—SILVANUS SURINAMENSIS, LARVA, ×20.

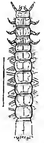


Fig. 181.—CUCUJUS HÆMATODES LARVA. (*From Chapuis.*)

CRYPTOPHAGIDÆ.

Antennæ with a three-jointed club. Tarsi five-jointed, rarely heteromerous in males. Five abdominal visible ventral segments, first longest.

Small oblong beetles, pubescent above, found in mushrooms and decaying plants. Ten Indian species are described by Motschulsky Reitter and Grouvelle.

HELOTIDÆ.

Five visible ventral segments. Basal tarsal joint reduced.

This is a small family of beetles resembling the *Erotylidæ* in appearance and found feeding on the flowing sap of trees. *Helota* is represented by twenty species from the hills, mainly described by Ritsema (Notes, Leyden Mus., 1893-1901). *Helota mellyi*, Westw., is described and figured from Simla (Cab. Or. Entom., Pl. XLI, Fig. 8). *H. servillei*, Ho. (Coleopterists' Manual, 3, p. 187) from Poona and *H. Guerinii*, Ho. (loc. cit., p. 188), are the previously described Indian species.

THORICTIDÆ.

Antennæ clubbed; prothorax large, elytra short. Tarsi five-jointed. Head sunk in prothorax.

A small family of peculiar beetles, of which very little is known, and which are separated on the above structural characters. *Thorictus heimi*, Wassm. (Fig. 153), is myrmecophilous and *T. indicus*, Grouv., was found at Belgaum.

EROTYLIDÆ.

Antennæ with a three or four-jointed club. Tarsi with five joints the fourth joint reduced in some forms, the basal three often broad and pubescent.

A moderately large family of small beetles, found chiefly in mushrooms and plant stems, where also their larvæ live. The fourth tarsal joint is so small as to be scarcely visible and they appear to have four-jointed tarsi. The individuals of the family will scarcely be distinguished by the above characters and the accurate diagnosis of the family includes the trophal characters also. Males and females are much alike with no marked sexual characters. Apparently no Indian species has been reared and but few larvæ are known at all. The greater number of the species are found in the New World: Fowler and Kuhnt have listed the family in Genera Insectorum (1909). *Languriinæ* are represented in India, by elongate slender beetles, the elytra with metallic blue or green colouring, the prothorax dull red or metallic green; they are found on the leaves of plants but not apparently in the plains. One species (*Tetralanguria elongata* F.) is very common in the hills and can be caught in numbers. This genus in America contains the "Clover Stem Borer" (*T. mozardi*. Lac.) a minor pest and the Indian species will probably be found to be borers in plant stems also. A total of 35 species are described from India, wholly hill forest insects.

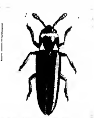


Fig. 182.—Tetralanguria elongata.

Erotylinæ.—A total of 31 species are known, from hill and forest localities almost wholly. *Amblyopus*, *Triplax*, *Aulacochilus*, *Episcapha* are the commoner genera. Gorham's papers on the collections of Andrewes should be consulted. (Ann. Soc. Ent. Belge., 1895, p. 328, 1903, p. 323.)

Mycetophagidæ.

Antennæ with a two or three-jointed club. Tarsi four-jointed, the anterior tarsi three-jointed in males.

Small beetles of dull colour found in "Mushrooms" and under the bark of trees. No Indian species are recorded, though several are known from Ceylon.

Coccinellidæ.—*Ladybird Beetles.*

Tarsi apparently three-jointed, the second joint expanded and pubescent. Antennæ short, not clubbed.

These small beetles are most readily recognised by their oval or rounded form, and their warning colours which include black, red,

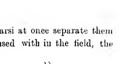


Fig. 183.—A. Coccinellid B. Chrysomelid tarsus.

yellow and brown, alone or together. The tarsi at once separate them from the family they are most readily confused with in the field, the *Chrysomelidæ*, these having apparently four-jointed tarsi. They are most closely allied to the *Endomychidæ* but differ in the antennæ, which in the latter are clubbed. These beetles are rarely more than one-quarter of an inch long; the head is small and nearly hidden by the prothorax (see *Hippodamia*) which fits smoothly into the rounded elytra. The antennæ are not distinctly clubbed, moderately long. The short biting mouth parts are not conspicuous. The legs are short, hidden under the body and formed for running. Males and females are not distinguishable on superficial characters and are of the same size, as a rule, the male sometimes smaller.

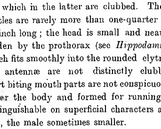


Fig. 184.—Chilocorus nigritus larva × 8.

The life-history is well known and several Indian species have been reared. Eggs are laid in clusters, openly on the plants, and are cigar-shaped yellow bodies laid on end. -- (Plate XVII.) The larvæ are active, widest in the middle and tapering to either end; the head is small, the thoracic segments broad. Each segment has spines or tubercles bearing hairs. The abdomen tapers and there is an anal foot which assists locomotion. Most are black or slate coloured, some a vivid red and a number have waxy processes similar to those of the mealy bugs on which they feed and which render it difficult to distinguish them from their prey. When full grown, they pupate openly on a plant, the larva firmly fixing itself by its anal foot and the pupa remaining often partly enveloped by the larval skin which bursts along the dorsal surface. The larval, as the pupal, life is short, the whole life history occupying but a short time, often not more than three weeks.

PLATE XVII.—CHILOMENES SEXMACULATA.

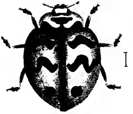
THE SIX-SPOTTED LADYBIRD BEETLE.

Fig. 1. Egg when laid.
„ 2. „ just before hatching.
„ 3. Larva, first instar.
„ 4. „ third „
„ 5. „ fourth „
„ 6. Pupa.
„ 7. Imago.
„ 8. Cotton plant with aphides.
„ 9. Egg cluster on leaf slightly magnified.
„ 10. Larva „ „ „
„ 11. „ „ „
„ 12. Imago „ „ „

The black hair-lines show the actual size of the figures 1—7, and the white ones on the plant those of 8 to 12 on the plant.

1

2



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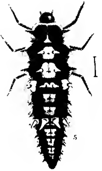

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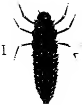

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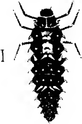

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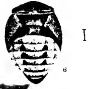

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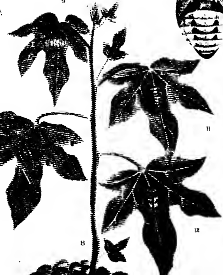


8

Hibernation or periods of scarcity are universally passed in the imago stage, the beetles living for long periods without food and awaiting the proper conditions for egg-laying. The imago is protected by the exudation of oil, in some cases, an acrid yellow fluid being excreted at pores on the margin of the prothorax or at the joints of the legs. With the exception of *Epilachnides*, nearly all are predaceous upon scale insects, mealy-bugs, aphides and similar small forms of life. Many species are known though no complete list of Indian forms is available. The most important of the plains forms are described below: this by no means exhausts the common species, and much has yet to be learnt of the species which prey upon the less evident forms of pests. Each species appears to have a well defined series of prey, which it exceeds only when it must, and we know little of what preys upon the rarer species of Aphides and Coccides.

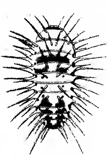


Fig. 185.—CHILOCORUS NIGRITUS LARVA × 8.

A great deal has been written about the value of introducing ladybird beetles to destroy scale insects and the like: hundreds of trials have been made, a regular exchange of *Coccinellids* was established and, as a result, there was one real case in which good resulted. Unfortunately, the idea has been taken up by the Press at different times and still crops up. Ladybirds, like parasites, do their best where nature puts them, but cannot be moved about the world to eat indiscriminately. The species of this country play an essential part in maintaining an equable balance of life, and we have a large number of useful species which would repay more careful study. *Coccinellids* are divided into two series those with simple or bifid mandibles which feed on insects, and those with many toothed mandibles which feed upon plant tissues. All of the species mentioned are confined in the first series, excepting *Epilachna*. Crotch revised the family in 1874 and since then Gorham has described numerous species (Ann. Soc. Ent. Belge, 1892, 1894, 1895, 1903) as has also Weise (Ann. Soc. Ent. Belge, 1892, 1895 and

Stettiner, Ent., Zeit. 1908). We may divide the family into the *Coccinellinæ* insectivorous, *Epilachninæ* herbivorous; the former may be divided again. Of the *Coccinellini*, 84 species are recorded, of the *Chilocorini* 33, of the *Scymnini* (*Scymnus*) 29, *Exoplectrini* (*Vedalia*, etc.) 10, and of the *Rhizobiini* (*Aulis*) five species. In the *Epilachninæ* 38 species are described. These beetles are extremely variable in size, colouring and markings; climate exerts a marked influence on them, and it is possible the number of distinct species is not really so large.

Coccinella includes three common species, two of which are widespread in our limits. *C. septempunctata*, Linn., is the abundant Seven-spotted Ladybird which is found on wheat and mustard. The larvæ are slate coloured with yellow spots, very active and feeding voraciously on the wheat aphis (*Macrosiphum granarium*, Kby.) and the Mustard aphis (*Aphis brassicæ*, Linn.). The beetle is red with three black spots on each elytron and a joint one at the scutellum, with some white on the prothorax and head. In the hills, as in Europe, the size of the black spots is constant; in the plains it varies immensely and some beetles have them so large that they fuse and almost cover the elytra. Like their prey, this species is found only in the cold weather in the plains; the beetles have been found to go into dense grass and other sheltered spots in March where they *apparently* remain until the following cold weather. This species is a very important check on the increase of the Aphides it feeds on and one of the most economically valuable insects in India. In the Punjab (and rarely further South), we find also the Eleven Spotted species, *C. undecimpunctata*, Linn., with a similar life-history and habits. Both are palearctic insects which have spread into the Punjab and further south and adapted themselves to the conditions by a prolonged period of rest; the evidence points to this period of rest being passed in the imago stage. This species has only once been found in Behar while it is very common in the Punjab. Its usual southern limit appears to be in the United Provinces.

C. repanda, Thunb., is a widespread insect in the plains, the spots in the form of three black curved bands and a small central spot; it is found abundantly in the cold weather feeding on mustard aphis, (*Aphis brassicæ*), and is reported to feed on *Aleurodes bergi*, Zehn., in Java.

Thea cincta, Fabr., is a round yellowish insect found feeding on the fruiting bodies (Perithecia) of the fungus that attacks mulberry leaves (***Phyllactinia corylea***, Karst.). Larvæ were reared upon this material and a great number of individuals were found on the mulberry bushes. It presumably has other food also.

Chilomenes sexmaculata, Fabr., is the commonest species in the plains. It is a small rounded beetle, varying in colour from red to canary yellow, usually yellow. It deposits eggs on the leaves of the cotton plant, among or near an aphis colony. Each egg is oval, almost cigar-shaped, about one-twentieth of an inch long, light yellow in colour. (Plate XVII.) In captivity a beetle lays about 90 eggs in clusters of about 9 each. These eggs hatch in four to five days, a small spinose larva appearing which at once begins to feed on aphis: it runs actively about seeking aphides and crushed skins of the victims testify to its rapacity. In captivity each larva required about 200 aphides a day and lived thus for 10 to 13 days. The young larva is black, with long legs, the body tapering to the hind end; as it grows older, white spots appear and the full-grown larva is black with yellow and white blotches. Pupation takes place on the leaf, the larva fixing itself by the tail, the pupa only partly emerging from the cast skin in some cases. The beetle emerges after four to six days and also feeds on aphis. Besides the Cotton Aphis (*Aphis gossypii*, Glov.), this species feeds on *Aphis cardui*, Linn., and on *Aphis adusta*, Zehnt. When food is not available, the beetle waits, hiding in shelter until food is again forthcoming and eggs can be laid. These periods of rest may be of many weeks' duration, but if food is available, the species goes on breeding except in the very cold weather.

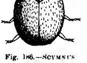


Fig. 186.—SCYMNUS XERAMPELINUS, × 8.

Scymnus includes the smallest species, round pubescent beetles of usually dull brown or black colour. *Scymnus xerampelinus*, Muls., is common, feeding on cotton aphis (*Aphis gossypii*, Glov.); the larva is clothed in white waxy processes which make it look like a mealybug: a single larva required 75 aphides daily for its food and lived 7 to 10 days. The pupa remains in the cast larval skin, emerging as a beetle after a week. This species occurs with

S. nubilans, Muls., throughout the plains, feeding also on cotton mealybug. We figure *Aulis vestita*. Muls (Pl. LXXXIV. Figs. 7, 8, 9), found feeding upon *Monophlebus*. This beetle and its larva are found on trees infested by this mealybug and would readily escape notice. Like its prev the beetle appears only from February or earlier to May, and breeds freely at that time; the beetle is found during the rains in concealment on the bark, awaiting the return of *Monophlebus*. (Mem. Agric. Dept., India, Vol. II, No. VII.)

Chilocorus nigritus, Fabr., is a moderate-sized round black beetle, very shiny, which feeds on *Aphis cardui* as well as several scale insects (*Asterolecanium*) and aphides. It is widely distributed but rarely found abundantly. *Brumus suturalis*, Fabr., is yellowish with black stripes on the elytra. It feeds on cotton aphis, cotton mealybug and probably other small sucking insects The larva was reared on *Phenacoccus insolitus*, Gr.; it is a sluggish insect, grey covered with a fine white bloom, measuring about five millimetres in length, two and a half in breadth, the abdomen being the thickest part. It eats the mealybugs in all stages and pupates among them in the usual way. *Clanis soror*, We., is a small round beetle found feeding upon the Castor Mealy Wing (*Aleurodes*, Sp.). The stages are figured. (Plate LXXXI, Figs. 9, 10, 11.)

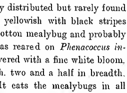


Fig. 187.—Epilachna viginti-octo-punctata.

Epilachna is herbivorous and is universally distributed. The beetles are comparatively large for this family, of a dull red-brown colour with black markings. The variability of the markings has led to the species having many names and it is not clear how many species there are. Our common ones fall into two types, *E. dodeca-stigma*, Muls. with 12 spots. *E. vigintiocto-punctata*, Fabr., with 28. These vary in colour, in size and number of spots, in extent of pubescence, and in the extent to which the colour is obscured by dark suffusion. So far as can be seen the life-history is the same throughout the common Indian forms; eggs are laid in clusters on the leaves, which hatch to oval yellow grubs with spiny processes; these feed on the epidermis of the leaf and pupate there when full grown, in the ordinary manner.

Cucurbitaceous and Solanaceous plants are their food and they may be destructive when abundant.

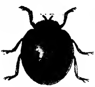


Fig. 188.—EPILACHNA DODECA-STIGMA.

Collecting.—Coccinellids are of such importance that no opportunity of collecting should be lost. Above all, when collecting, it is useful to search carefully for their food: the value of each species depends wholly upon their food and while some are restricted to one or a very few insects, others are probably less restricted. The question of food also determines the times at which they are prevalent and we are still largely ignorant of how these insects pass through the year. Coccinellid larvæ are very easy to rear if given sufficient food and the adults, if well fed, lay eggs freely in captivity.

ENDOMYCHIDÆ.

Antennæ moderately long with a three-jointed club. Tarsi apparently three-jointed but really four-jointed; the basal two joints broad.

These beetles are distinct from all but the preceding (*Coccinellidæ*) in the peculiar tarsi: the longer clubbed antennæ further separate them from *Coccinellidæ*. The family is not a large one; all known are apparently feeders on lichens and fungi, and are found in concealment often gregariously. They are characteristic of moister warm areas than the plains of India. The transformations of several species have been recorded in America and Europe, but much remains to be learnt. The student should consult Gorham's papers: the species of Ceylon are described (Proc. Zool. Soc., 1886, p. 154) and some new Indian species (loc. cit. 1897, p. 456, Ann. Soc. Ent. Belge, 1895, p. 328, 1903, p. 323). Nineteen Indian species are recorded.

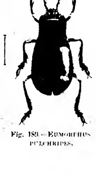


Fig. 189.—EUMORPHUS PULCHRIPES.

DERMESTIDÆ.

Tarsi with five-joints; antennæ short with a club, and received under the prothorax in a cavity. Head retractile.

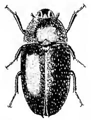


Fig. 190.—Dermestes vulpinus F. × 4½.

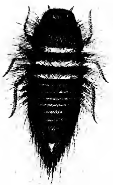
These small beetles are not readily separated from those which come nearest to them unless the life-history is known, the commonest species, which are household pests, having characteristic larvæ. The beetles are often clothed with fine hair or scales. The head in some bears a median ocellus. The apical joint of the antennæ in the males may become enlarged.

The life-history is known in general but of no Indian species except the household ones. The larvæ are predaceous or feed upon dried animal matter. The free-living larvæ are found under the bark of trees and in similar situations where there is a quantity of insect larvæ on which they can feed. Household species feed upon skins, horns, wool and similar dried animal matter. The larvæ are characterised by the development of tufts of long hairs (Plate XVIII), which in some cases reaches an extraordinary development, especially in the predaceous free-living species. The reader should consult the figure in Sharp's Insects for a typical free-living Dermestid larva, such as is found under the bark of trees. Other larvæ are provided with small terminal and lateral tufts of hairs, capable of being moved and extended. These larvæ eat into their food, making holes in skins or horns and completing their metamorphosis there. The length of the life-history is not known but it can be very greatly extended in every stage, if food is scarce. It is known that the eggs are capable of remaining unhatched for long periods, that larvæ will starve and that the pupal stage may be a very long one. The pupa is commonly found almost wholly enveloped by the larval skin which is not shed but only splits along the dorsum. Several household species are likely to be found, having been recorded several times; these are cosmopolitan insects spread by commerce.

PLATE XVIII.—ANTHRENUS VORAX.

THE WOOLLY BEAR.

Fig. 1. Larva, dorsal view. x 12.
,, 2. Young larva, feeding on a bristle. x 12.
,, 3. Pupa, in the larval skin, which is open along the dorsal line. x 10.
,, 4. } Imago. x 16.
,, 5. }
,, 6. Egg. x 20.



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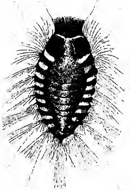

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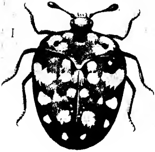

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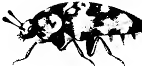

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The recorded species are less than twenty, including the cosmopolitan *Dermestes cadaverinus*, F., and the species mentioned below.

Dermestes vulpinus, F., whose larva feeds upon the cocoons of silk worms, is common in India, as elsewhere. It is curiously fond of these cocoons eating through the silk to reach the pupa within, on which it feeds. Cleghorn mentions it as a destructive insect to silk in India, the cocoons having to be quickly reeled off to avoid loss. (Indian Mus. Notes, I, p. 47.) Silkworm cocoons (containing pupæ) must be so packed that the beetle cannot get access to them or the cocoons on arrival will probably be infested and partly spoiled. *Dermestes* larva is elongate, cylindrical, tapering behind; the prothorax is large, the hind end bears two dorsal hooks and a ventral anal tube. Each segment has a dorsal plate, behind which is an erect row of long hairs and a backwardly directed row of stiff hairs; there are longer hairs on the sides, and a third row on the prothorax. *Aethriostoma undulata*, Motsch., is found in wheat. Its larva is broad, with short hairs, with no anal tube or hooks. The part it plays in wheat is not ascertained but it is likely to be predaceous upon the other insects there or to feed on their dead bodies. The larva of *Attagenus* is similar but the segments are completely hardened above and each segment fits over the next; there are no hooks or anal tube, and each segment is clothed in scales, with also a row of hairs which extend on to the sides: the hind end bears a bundle of hairs. *A. gloriosæ*, Fabr., probably occurs in India. The larvæ of *Anthrenus*, *Tiresias*, *Trogoderma*, are provided also with bundles of long hairs on the posterior segments, these hairs being moveable and erectile, often of peculiar form; in *Anthrenus* the bundles are on the three posterior segments. *A. vorax*, Wat., is known to attack skins and horns in India, as well as woollen clothes and the bristles used in making brushes, and is constantly reported as destructive. (Plate XVIII.)

BYRRHIDÆ.

Antennæ clubbed. Head retracted, tarsi five-jointed,
a prosternal spine fits a mesosternal cavity.

Small oval beetles, convex and short, of dark colour, found under stones and on the soil in temperate regions. They are vegetarian, one genus (*Chelonarium*) living also on the leaves of trees. *C. indicum*, Gr., lives in the plains of India but is rare. Motschulsky described five Indian and one Burmese species of *Byrrhinus*. Four other species are described, *Chelonarium indicum*, Grouv., being the most widespread.

GEORYSSIDÆ.

Antennæ nine-jointed, three forming a club.
Tarsi of four joints.

A tiny family of beetles distinguished on the above characters and chiefly found burrowing in soil in the Northern Hemisphere. Two species of *Georyssus* occur in Ceylon.

HETEROCERIDÆ.

Antennæ with a long seven-jointed club. Tarsi four-jointed.

Semi-aquatic beetles found burrowing in the mud of river-banks and tanks. They are capable of stridulating and on being seized, emit a sound. The life-history of the European species is known, the pubescent larvæ burrowing in mud. Little is known of the Indian species, six species being recorded. They are common in freshwater in India and come freely to light. The beetle is probably predaceous, feeding on the insect life of its habitat which is abundant and having its body and strong expanded legs formed for burrowing in the wet mud in which it lives.

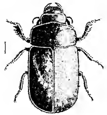


Fig. 191.—HETEROCERUS SP.

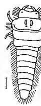


Fig. 192.—HETEROCERUS MARGINATUS LARVA. (*From Chapuis.*)

PARNIDÆ.

Antennæ variable. Tarsi five-jointed, the last joint large; prosternum produced in front to protect the mouth, behind to fit into the mesosternum. Aquatic.

Small beetles clothed in fine pubescence, found in water. They are seen clinging to plants, stems and other objects in running water for which purpose they have the enlarged tarsal joint and claws, and the pubescence holds a sufficiently large bubble of air to supply the needs of respiration. The pubescence in *Parnus* covers the whole body, which is thus set in a bubble of air, but in *Elmis* extends only along the ventral surface, to carry air to the spiracles. The family are possibly simply clavicorn beetles which have, from feeding on decaying vegetation near water, become aquatic and retain the same food habits. Their larvæ are also aquatic,wholly unknown as yet in India.

Less than ten species are recorded, in the genera, *Dryops*, *Parygrus*, *Stenelmis* and *Sostea*. *Dryops opacus*, Grouv., is the common species found frequently at light in the plains and hills.

CIOIDÆ.

Antennæ of eight to eleven joints, with a three-jointed club. Tarsi usually of four joints, the first small, the last long. Abdomen of five segments, first longest.

Small insects of cylindrical form, uniformly coloured in deep brown or yellow, with small impressed points on the elytra. The beetles are found in corky mushrooms, usually in all stages of development together. *Lyctoxylon japonum*, Reitt., is recorded from the Himalayas and Japan.

BOSTRYCHIDÆ.

Antennæ with a three-jointed club. Tarsi five-jointed, basal joint small, second and fifth long.

The family is recognisable most easily by the cylindrical form, the produced and tuberculate prothorax in many cases, and the general resemblance to *Scolytidæ*, from which they differ in the straight (not elbowed) antennæ, in which the apical joints are often expanded on one side only, and in their tarsi, which are five-jointed. They are small insects, scarcely as much as a quarter of an inch long and nearly always the dull black or deep brown of wood-boring and light-shunning insects. The body is cylindrical, the integument thickened and hard, the structure compact and the insect well fitted for boring tunnels in wood. The legs are short, the femora and tibiæ broadened, folding up under the body, the trophi are well developed and powerful. In many the front of the prothorax overhangs the head and is toothed and roughened, while in some the body terminates behind in a flat slope in which are tubercles, as if the hind end had been cut off obliquely and tubercles put in for the beetle to get a purchase on the sides of the tunnel. Males and females are alike in appearance, the former the smaller.

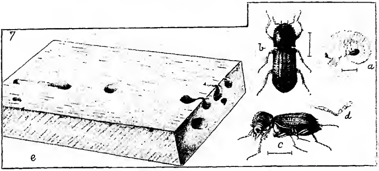


Fig. 193.—BOSTRYCHUS ÆQUALIS—LARVA, IMAGO AND BORED WOOD. [I. M. N.]

The life-history of some species is known and details must be sought in the literature of forest insects. In general, the beetles bore tunnels in wood, depositing eggs in these tunnels: the larvæ are white, the body white, soft and tapering behind, the apex curled round underneath. Thoracic legs are usually present, eyes are absent and there are small four-jointed antennæ. The larval food is the same as that of the imago; pupation takes place in the larval tunnel, no cocoon being formed. In the known common plains species there are at least two broods yearly, the beetles emerging after the cold weather, a brood being completed before the rains and a second brood commencing then; this may be a hibernation brood or may emerge and yield a third or hibernation brood. In warmer parts of the plains there is no hibernation but it is not known whether there are then more than three broods.

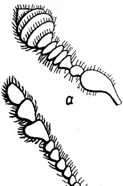


Fig. 194.—A. SCOLYTID. B. BOSTRICHID ANTENNA.

The family is of importance as it contains species which destroy cut timber or dry wood, as well as bamboos; in one species at least, stored grain and food products are attacked. The function in nature of these beetles is to clear away dead wood: when these beetles attack furniture and cut wood, as well as bamboos, they are serious pests. The bamboo-boring species are extremely common in the plains but the remainder are almost wholly forest insects and only found outside forest limits in dry wood. There are two special points about the bamboo-boring species that are worth note; there is a general belief, not confined to India, that bamboos must be cut at certain phases of the moon or they will be attacked by Bostrychids: this is probably connected with the rise and fall of sap, bamboos cut at one time containing less sap than those cut at another; secondly it is a general custom to soak bamboos in water for a number of days, after which they are not attacked; any one may observe the effect of this by using unsoaked bamboos in a roof: they are attacked very heavily and almost at once, while soaked bamboos are not; the explanation probably is that soaking removes not only sugar and soluble carbohydrates but also albumens, and leaves the bamboo without nutritious content.

These beetles suffer from a considerable number of enemies, small beetles which invade their tunnels and attack them or their young. ***Histeridæ*** of the genera *Teretriosoma* and *Teretrius* are found in their burrows and Lesne mentions a *Colydiid* beetle (*Bothrideres*) which lives upon *Sinoxylon crassum*. *Cleridæ* attack them also (*Cylidrus*, *Denops*. *Tillus*, *Opilo*. etc.), and a *Melyrid* (*Axinotarsus*) is also recorded. Hymenopterous parasites are known but are uncommon.

The family has recently been monographed by Lesne (Ann. Soc. Ent. France, 1896, p. 95; 1897, p. 319: 1898, p. 438; 1900, p. 473: 1906, p 445). He divides it as follows :—

- I. *Psoinæ*.
- II. *Polycaoninæ*.
- III. *Dinoderinæ*.
- IV. *Bostrichinæ*.
    - 1. Bostrichines. Bostrichi. Xyloperthi.
    - 2. Apatines.
    - 3. Sinoxylonines.

Of the *Polycaoninæ*, one Indian *Heterarthron* is recorded. The *Dinoderinæ*, *Bostrichines* and *Sinoxylines* are alone of any importance in India. In the first, five species of *Dinoderus* and one of *Rhizopertha* occurs in India. Of the *Bostrichines*, there are nine *Bostrichi*, and seven *Xyloperthi* recorded. In the *Sinoxylines*, 17 Indian species are recorded.

Dinoderus distinctus., Le., attacks the branches of mango. *D pilifrons*, Le., is bred in bamboos, both green and dry, as in wood. *D. minutus*, Fabr., is smaller than the preceding and is common also in bamboos. It was also found in cut sugarcane. *Rhizopertha dominica*, Fabr. (*pusilla*, F.), is a household pest boring into biscuits and other dry stored produce, as well as grain. It is apparently common in Indian houses and we have reared it from wheat flour. *Bostrichopsis parallela*, Le., is mentioned by E. P. Stebbing as boring in bamboos. *Bostrychus aequalis*, Wat. (fig. 192), was found in tea-boxes from Calicut. *Sinoxylon indicum*, Le., has been captured in many localities in South India and Burmah, but

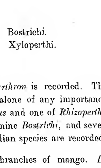


Fig. 195.—DINODERUS DISTINCTUS. [I. M. N.]

does not appear to have been reared. *S. anale*, Le., has a length of one-eighth to a quarter of an inch and is commonly found boring in cut

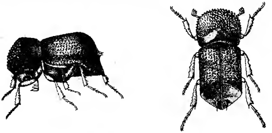


Fig. 196.—SINOXYLON ANALE, × 6.

and dead wood. A number of trees it infests are recorded, as well as bamboos; apart from its significance as a forest pest, it is likely to be found anywhere in the plains. It is the species twice referred to in Indian Museum Notes (III, p. 123, V, p. 113) and we have reared it from ordinary dry wood in Behar. *S. conigerum*, Gerst., is recorded in South India, and is widespread in the tropics. *S. crassum*, Le., is referred to by de Niceville (Indian Mus. Notes, V. p. 106) as boring in *Acacia catechu* and is known to attack the cut or dead wood of other trees.

PTINIDÆ.

Tarsi five-jointed. Antennæ often with a feeble three-jointed club. Head retractile into the prothorax.

Small beetles, often of cylindrical form, the integument hard: the tarsi are of five joints, the basal two subequal in length (c. f. Bostrichidæ). The colours are sombre, dark brown or black predominating. The antennæ are often feebly clubbed.

The larvæ are well-known as borers in wood, furniture, dried farinaceous matter, books, drugs and tobacco. These larvæ are of a form similar to the *Lamellicornia*, the body white and thickset, set with fine hairs, and curved back on itself; the head is small, with distinct eyes and small antennæ usually of two joints, the body is finely wrinkled, and there are three pairs of legs. These larvæ eat tunnels and are very destructive; pupation takes place in a cocoon in the tunnel. The beetles on emergence couple and lay eggs soon after.

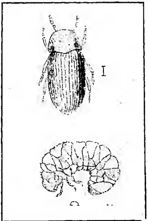
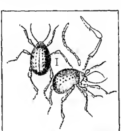


Fig. 197.—SITODREPA PANICEA—LARVA AND IMAGO.

The family, which is a large one, is divided into two, the *Ptinides*, with the antennæ inserted on the frons, *Anobiides* with the antennæ inserted on the anterior margin of the eyes. *Ptinus* includes the cosmopolitan *P. fur*, Linn., a museum pest, and *P. nigerrimmus*, Boi. *Gibbium* contains a cosmopolitan species, *G. scotias*, Czen., a small shiny brown insect with swollen and united elytra, and no wings. It is a household pest and is recorded (Indian Mus. Notes, I, p. 106) as feeding on the outer shells of opium cakes; the larva makes a hard whitish cocoon of anal secretion; we have reared it from the rubbish found in the bottom of a cupboard of papers in an office in Dharwar: the insect is common in Egypt and the East, feeding on all manner of dried animal and vegetable matter and is recorded from a box of cayenne pepper.



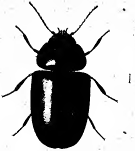
98.—GIBBIUM SCOTIAS. [I. M. N.]

Of the *Anobiides*, *Anobium* is the best known, the larvæ boring in dry wood and furniture, the beetles in the tunnels producing the knocking noise known in England as the "Death Watch." *Anobium* (Sitodrepa) *panicea*, Linn., is found attacking books, papers, dry wood and similar dried vegetable matter. The beetle and grub are both borers, making neat cylindrical tunnels in which they live. The

PLATE XIX.—LASIODERMA TESTACEUM.

THE CHEROOT BEETLE.

Fig. 1. Two eggs on a piece of tobacco leaf x 10.
,, 2 Larva, as it is usually covered with particles of leaf. x 12
,, 3. Larva divested of the covering. x 16.
,, 4. Pupa x 16.
,, 5. Imago, dorsal view x 12.
,, 6. ,, resting attitude x 16.
,, 7. *Bored cheroot.*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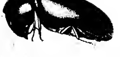
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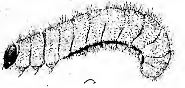
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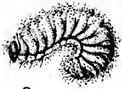
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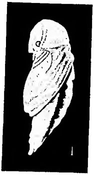
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beetle is said to knock with its head in the tunnels, as a signal presumably to others of its kind. This is a cosmopolitan insect and is common in books in this country. *Lasioderma testacea*, Duft. (Plate XIX), is slightly broader but otherwise similar in appearance, pubescent brown with five lines on the elytra. It bores in cheroots and cigarettes, the larva also boring in the same place. This insect is a serious pest in cured tobacco and any form is liable to become infested. The larva pupates in a case in the tobacco or between the cheroots and the life-history is a short one. It is recorded as attacking opium in the Gazipur Factory (Indian Mus. Notes, 1, p. 57) and is a well-known insect in South Indian tobacco factories. It may also be found in turmeric and probably other drugs sold in the bazaars. In addition to the above household species, nine species have been described from this country. No details of the lives of these free-living species are available.

MALACODERMATA.

This group may be divided as follows :—

Lycidæ.
Lampyridæ.
Telephoridæ (*Cantharidæ*). Here treated as *Malacodermidæ*.
Drilidæ;
Melyridæ. (*Malachiidæ.*)
Cleridæ.
Lymexylonidæ.
Rhagophthalmidæ.

Amongst important recent papers are Gorham's on the Andrewes collection (Ann. Soc. Ent. Belge, 1895, p. 294 ; 1903, p. 323 ; Proc. Zool. Soc., London, 1889, p. 96) and Bourgeois' papers (Ann. Soc. Ent. Belge, 1892, p. 7 : 1905, p. 46 ; 1906, p. 99 ; 1891, CXXXVII ; Bull. Soc. Ent. France, 1896, p. 117 ; Ann. Soc. Ent. France, 1903, p. 478 ; 1905, p. 127). For *Lycidæ*, Waterhouse's Illustrations of Typical Coleoptera, Vol. I, is valuable and the *Lampyridæ* are listed by Olivier in Genera Insectorum.

MALACODERMIDÆ.

Tarsi five-jointed. Integument soft. Six, seven or eight ventral segments.

This family is a large assemblage of forms which are difficult to define accurately but which are, as a general rule, easily recognised.

The colours are often sombre, though many are yellow and a few a vivid red. They vary in length up to nearly half an inch. The body is flattened, the integument soft, the body without that hardness and rigidity which is a feature of most beetles. The head is generally concealed under the prothorax ; the antennæ are often pectinate, sometimes moniliform, serrate or vaguely clubbed. The large flat pronotum fits loosely to the elytra, the latter lying over the abdomen but not accurately adapted to it. The mouth-parts are usually feebly developed. Sexual differences are marked in a number of characters (most easily in the larger eyes which are often contiguous in the males) and some

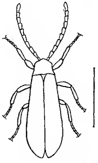


Fig. 199.—MACROLYCUS BOWRINGI.

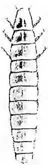


Fig. 200.—MALACODERMID LARVA, × 3.

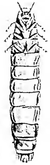


Fig. 201.—MALACODERMID LARVA, × 3. THE LIGHT PATCHES ON THE APEX OF THE ABDOMEN ARE LUMINOUS.

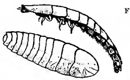


Fig. 202.—LUMINOUS MALACODERMID LARVÆ OR FEMALES, × 1.

females never attain to the winged form but remain as incompletely matured insects or are of the form of the males but with incompletely developed wings. The females of many species are unknown.

Though these beetles are among the most abundant of Indian insects, little is known of their metamorphosis. They are themselves found in the moist warm parts of India in great abundance, in the drier parts of India in the rainy season only and less abundantly. The beetles are found during the day on plants, the brightly coloured ones openly, others in concealment, and they come out at night, only for a short time at a regular hour. Some are probably vegetable feeders, some predaceous, and their larvæ are, in some cases, known to be predaceous on molluscs. One appears to have been reared in India; the larva of *Lamprophorus nepalensis* is mentioned and figured :—(Ritsema. Tiydschr, Ent. XXXIV, p. CXIV, and Notes Leyden Mus. XIII, pl. X, 1891).

In moist localities, as in the submontane forest areas, are found the peculiar flat larvæ (Fig. 201) of the sub-family Lampyrinæ. These insects are often over one inch long, the segments flattened, the notum forming a flat plate which covers the segment; the head is concealed under the large pronotum and is protrusible, with small antennæ, slender curved mandibles and inconspicuous mouth-parts. There are three pairs of short legs, and the ventral surface of each segment has a brush of short stiff hairs; from the apex of the abdomen are protruded a bunch of soft slender filamentous processes which act as a sucker and give a firm hold on the soil. These are retractile and are normally completely retracted into the rectum. On each side of the eighth abdominal segment is an oval white patch which becomes luminous at the will of the insect. The reduced spiracle occupies the middle of this patch, the remaining spiracles being larger. This luminosity is very striking, a bright greenish white light being emitted. The light is evidently under the control of the insect and can be quickly produced, though on the cessation of stimulus it fades only slowly. The luminous patches are on the ventral surface and though the overlapping dorsal plate is to a large extent transparent, the light is emitted principally upon the ground. These insects are nocturnal, are dependent upon moist conditions and feed upon snails. A large specimen required at least six small snails daily and with sufficient moisture and enough snails throve in captivity. The luminosity is not used in feeding; the insect seizes a snail, curls over on its back with the snail held in its legs and slowly devours the muscular part, leaving the alimentary canal. This has been observed frequently and the luminous organ is not functional. What purpose this organ serves in a larval insect is not clear unless it be defensive. Quite young specimens exhibit it and though none of these larvæ have been reared, all that have been observed in India are sexually immature and evidently larval. It is to be hoped that these curious insects will be investigated by an observer situated where they are abundant and that the species to which they belong may be determined by rearing them to maturity. Olivier states that while the larvæ are well known, in no single case has a larva been reared and the imago identified. A larva, apparently of this group, was found in Behar (Figs. 199, 200), an elongate, slightly flattened insect, of a dull reddish tint with soft integument; the legs were well developed, and at the apex of the abdomen below were two light-emitting patches. Apparently this was a mature larva seeking a place in which to hibernate or pupate.

The nature of the luminosity of these insects has been much discussed; certain tissues of the bodies of these beetles have the power of giving off light, just as other tissues exert a mechanical action or emit electrical energy. The luminosity is under the control of the insect and heat is not produced. It has been remarked that these insects can convert a quantity of energy into its full equivalent of light without loss due to the production of heat; no means are known of doing this artificially and even the most modern devices for light production convert only a fraction of the energy into light. The precise object of this luminosity is not clear: while most of the beetles are nocturnal, a few are actually diurnal in habit and the luminosity would not appear to have any value. In the case of nocturnal species, the emission of light may serve as a "warning signal" to bats and nocturnal birds but there is little to support this view. It is more likely that this property is connected with sex, but it is also possible that it is a part of the vital activity of the insect which has no function but an ornamental and pleasing one. It is worth noting that the luminosity is greatest in those species which have the least developed antennæ; forms with long pectinate antennæ are the least luminous.

In India the Lampyride division of this family includes the only luminous insects: the only other light-emitting insects in which the light is the direct production of the insect's tissues are the species of *Pyrophorus* (*Elateridæ*), which are confined to the Neotropical Region.

This large family is divided into sub-families (tribes) as follows :—

I. Antennæ inserted on the frons or at the base of the rostrum dorsally.
  (*a*) Intermediate coxæ separated. 1. *Lycinæ*.
  (*b*) ,, ,, contiguous, antennæ sub-contiguous. 2. *Lampyrinæ*.
  Antennæ distant. 3. *Telephorinæ*.
II. Antennæ inserted laterally in front of the eyes.
  (*a*) Clypeus not distinct. 4. *Drilinæ*.
  (*b*) Clypeus separated by a suture. 5. *Melyrinæ*.

Lycinæ.—Over fifty species are recorded from India, largely from hill forest localities. Red and orange are prevailing colours in our species; the beautiful *Lycostomus præustus*, Fabr., is found in the plains, a deep orange insect with the elytra tipped with black. We have seen bushes so clustered with red *Lycostomus* as to appear to be covered with red blossoms. *L. rufiventris*, Wat., is another of our species, the colouring bright red; it rests by day openly on a plant or grass stem, and is active at night only.

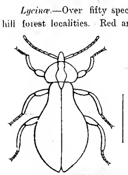


Fig. 203.—LYCOSTOMUS THORACICUS

Lampyrinæ are monographed by E. Olivier in Genera Insectorum (1907).

Indian species are as follows :—

Lucidotini ..	.. *Lucernuta* 9.
Lamprophorini ..	.. *Lamprophorus* 10.
	Diaphanes 17.
	Lampyris 1.

Megalophthalmini	*Harmatella* 2.
Luciolini	*Luciola* 31.
	Pyrophanes 1.

Diaphanes marginella, Ho., *Luciola Gorhami*, Rits. and *L. ovalis*, Ho., are the light-emitting species so abundant in trees at night during the rainy months. The males have a larger luminous area (three segments) than the females (two segments) and are extremely bright and vivid in some cases.

Telephorinæ.—Over fifty species are described from the continent, but one of which occurs in the plains. This is *Tylocerus bimaculatus*, Ho., a yellow insect with a black blotch on each elytron, the male with the basal and apical segments of the antenna dilated. In *Silis*, the male antennæ are beautifully pectinate, the beetle flying or walking with the antennæ stretched out, each branch very long and erect, giving the appearance of a frond of a delicate plant. Insects with such specially developed antennæ are not uncommon in deep forest and presumably these structures are associated with special senses.

By some authors, the name *Cantharis* is associated with an insect of this family, which would then be known as the *Cantharidæ*; this would create profound confusion in the mind of the student, who associates the term, in all literature up to now, with the blister-beetles below. To such authors. the *Scolytidæ* are *Ipidæ*, the *Bruchidæ* are *Lariidæ* or *Mylabridæ*, the *Trogositidæ* are *Temnochilidæ* or *Ostomidæ*, the *Parnidæ* are *Dryopidæ*, the *Ptinidæ* are *Anobiidæ*, the *Cistelidæ* are *Alleculidæ*, and so on. It is to be hoped that such alterations in the nomenclature will, by the general consent of Entomologists, be barred; the tendency to change names long in use on account of some purist's discoveries in priority is deplorable: the work of practical and teaching Entomologists is being burdened with an immense nomenclature constantly increasing in complexity, and the difficulties of the student are greatly increased. To convert *Heliothis armigera* to *Chloridæ obsoleta*, to call *Locustidæ Phasgonuridæ*, to change the significance of such names as *Mytilaspis*, *Dactylopius*, *Lecanium* and *Coccus*, (each with a clear significance to the practical worker) are instances of this practice referred to elsewhere in these pages and which the student should clearly understand.

Drilinæ.—This sub-family includes less than twenty Indian species. ***Selasia laticeps***, Pasc. and ***Dodecatoma bicolor***, Westw., are to be found during the rains, delicate yellow and black insects, with pectinate antennæ.

Melyrinæ. (*Malachiinæ*).—These beetles are of small size and bright colouring, active by day in some cases and found occasionally in great abundance at flowers. The larvæ are not known. Over thirty species are described and several are common in the plains. *Hapalochrus fasciatus*, F., is a small beetle, coloured in orange and metallic blue, found running on crops and small plants. *Laius jucundus*, Bourg., is smaller, an equally brightly coloured insect, which runs actively about in grass and on soil. *Prionocerus bicolor*, Redt., is a large yellow insect, with the appearance of the typical members of the family. *Melyris* is represented by a small pubescent black insect found abundantly on the flower heads of *Artemisia* in the hills. It is quite unlike most *Malacodermids*, more compact and chitinised, and much smaller. *Idgia* includes the typical forms, brightly coloured insects which are active by day and feed on the anthers and stigmas of plants. *Idgia cardoni*, Bourg., has been found to be destructive in this way, though not on any scale, destroying the flowering parts of cereals and preventing fertilisation.

CLERIDÆ.

Antennæ clubbed, dentate or flabellate. Lamellæ under the tarsal joints. Tarsi five-jointed, but basal joints of posterior legs often very small.

Brightly coloured insects, of small size, the majority with warning colouration. Many are banded in bright colours, some uniformly blue or other metallic colours. The shape is characteristic, the head and thorax narrower than the elytra, the sides parallel, the body cylindrical. The antennæ are feebly knobbed, moderately long. The head is prominent, the prothorax distinct, the elytra covering the abdomen. The legs are of moderate length, formed for running.

These little beetles are active in flight and are found in the open on flowers, on trees, in grass, on fallen wood, at carcases. Some are predaceous upon other insects, notably those that bore in wood and bamboos. The bamboo boring *Bostrichids*, as also wood-boring

Scolytids, are their prey and the larvæ have the same habits. Little is known of the habits of the larvæ as a whole, some being predaceous, some scavengers and some being known to live in the nests of bees and in locust egg masses. With the exception of those that prey upon wood-boring beetles none appear to have been reared in India.

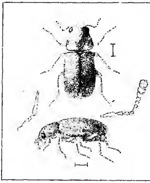


Fig. 204.—NECROBIA RUFIPES.

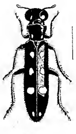


Fig. 205.—CALLIMERUS DECORATUS.

The family is a large one, the latest monograph (Genera Insectorum) giving nearly 2,000 species, of which 109 are Indian. They are less common in the cultivated plains than in the hill forest areas and the warmer moist parts of India. Gorham describes Doherty's Indian and Burmese species (Proc. Zool. Soc., London, 1893, p. 566), and Fea's (Ann. Mus. Genova, 1892).

Few are likely to be found unless they are specially looked for, and there are probably many species to be found in the plains. The following are noteworthy :—*Necrobia rufipes*, F., a bright blue insect, is cosmopolitan and is, with *N. violacea*, L., a household pest feeding on animal produtcts (horn, etc.). *N. ruficollis*, F., in which the thorax and base of the elytra are red, is known to be destructive to the dry cured fish prepared in Sylhet. *Corynetes cœruleus*, de G., is also cosmopolitan and carried by commerce. *Ommadius indicus*, Cast., is a larger dark-banded brown insect, found in Southern India. *Tillus notatus*, Klug., is found in abundance in the burrows of bamboo-boring

Bostrichids and, in bamboo-roofed buildings, is at times extremely abundant. Its larvæ are supposed to live in the burrows, feeding on the larvæ of the *Bostrichids*: it is probably an important factor in checking this pest. We figure *Callimerus decoratus*, Gorh., as an example of the vividly marked species so common in forests; the ground colour is deep blue, the spots are dense white and the legs are yellow. *Opilo subfasciatus*, Westw., *Orthrius bengale*, Westw., and other species of *Orthrius* are found in the plains, brown and black species that frequent flowers and which suggest small longicorns.

LYMEXYLONIDÆ.

Tarsi of five joints, first and fifth long, remainder short. Antennæ short, serrate.

Elongate cylindrical beetles, whose larvæ are cylindrical and bore galleries in dead or dying trees. They are a very small family and doubtfully distinct from both *Malacodermids* and *Melandryids*. They are extremely widespread and occur in tropical forests in the East. *Atractocerus* occurs in Ceylon and is likely to occur in India.

RHAGOPHTHALMIDÆ

This family includes two Indian species *Rhagophthalmus brevipennis*, Fairm., from Nagpur and *R.* (Ochrotyra) *semiusta*, Pascoe, from the Nilgiris.

DASCILLIDÆ.

Tarsi five-jointed. Abdominal segments five.

A small group, near to the *Malacodermidæ* and doubtfully homogeneous or distinct. Most are American and European. Less than twenty species are recorded from localities in India: of their habits nothing appears to be known.

RHIPICERIDÆ.

Antennæ flabellate or pectinate in the males. Tarsi five-jointed, the fifth joint with a well-developed setaceous onychium. Anterior legs with trochantin.

A family, closely related to the *Malacodermidæ*, of small numbers and but little known. The antennæ in one genus, *Rhipicera*, have more than the usual eleven segments, as much in some cases as forty. The beetles are not common and are essentially tropical. Three species of *Callirhipis* occur in India.

STERNOXI.

Schwarz gives the following classification of the *Sternoxi* :—

Buprestidæ.	*Elateridæ.*
Throscidæ.	*Dicronychidæ.*
Eucnemidæ.	*Plastoceridæ.*
Cerophytidæ.	*Cebrionidæ.*

The *Eucnemidæ* are monographed by Bonvouloir (Ann. Soc. Ent., France, 1870) and the *Cebrionidæ* in the same publication, 1874. The student will also find Maindron's *Elateridæ* in this publication for 1905, p. 319. *Elateridæ* are listed by Schwarz and *Buprestidæ* by Kerremanns in Genera Insectorum.

BUPRESTIDÆ.

There is a prosternal process extending back into a mesosternal cavity. The antennæ serrate, short. Tarsi five-jointed, basal four joints with pads.

These beetles resemble *Elateridæ* superficially but have not the hind angles of the prothorax produced backwards. They include tiny beetles less than one-quarter of an inch long as well as large robust forms nearly one inch in length. The colours are usually metallic, from dul

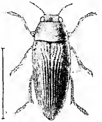


Fig. 206.—PSILOPTERA FASTUOSA.

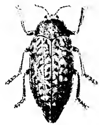


Fig. 207.—JULODIS ATKINSONI.

bronzy black to bright green with red reflections. Some species are covered with an efflorescence produced from a secretion in the skin. Warning colouration is not usually shown and the exact significance of the colour schemes is perhaps doubtful. The integument is hard and strong, the head partly sunk in the thorax, which is strongly fixed to the abdomen, the elytra accurately adapted to the body; the antennæ are readily concealed under the head. The mouth-parts are short and of the herbivorous type. The legs are short and fold under the body when at rest. The wings are large and functional in flight. Males and females are similar in appearance and usually also in size. The life-history of a few species has been worked out in India and agrees with that of the group as a whole. The larvæ are borers in the tissues of plants, some mining in the leaves, others boring in the twigs, the branches, the woody stems or beneath the bark of trees. The larva is of a characteristic form, legless with the thoracic segments swollen into a distinct bulb (Plate XX), the abdomen very long and slender. The swelling fits the bore made in the plant and gives the larva the necessary hold to move along the bore or to work with its mandibles against the hard tissues. Pupation takes place in the bore, the pupa lying naked in a chamber made by closing the bore with debris, as a rule; the larva prepares the hole of exit for the pupa, leaving only a thin covering of bark through which the beetle can readily emerge. The beetles feed on leaves, eating the parenchyma and leaving the veins only. They fly actively and are diurnal.

The large species have a life-history lasting one year at least, and the beetles are seen at one season in the year only. Some at least of the smaller species have several broods in the year depending upon their foodplants. Hibernation appears to be passed in the larval and in the imaginal states. A few are pests, those which breed in cultivated plants such as guava, cotton, jute, groundnut and citrus trees. The family is of more importance in Forestry than in Agriculture. Hymenopterous parasites attack these larvæ just as they do other boring larvæ, and birds are known to feed on the beetles.

This family is a very large one and widely spread, with nearly 300 recorded "Indian" species. Kerremanns divides the family into 12 sub-families, which need not be touched on here (see Ann. Soc. Ent., Belg., XXV, p. 165); he has recently listed the known species in Genera Insectorum and is monographing the species of the world. By far the larger number of recorded Indian species are Himalayan or Burmese. A very small number are common in the plains with a small number that have been occasionally recorded.

Sternocera includes large brightly coloured species, of somewhat oval shape, with smooth elytra and deeply punctate pronotum, the sternal process prominent. They are rarely found outside the hills and forest areas. *S. chrysidioides*, C. & G., and *S. nitidicollis*, C. & G., being occasionally captured.

Julodis is of similar form but without a marked sternal process, the elytra pointed at the apex. *J. atkinsoni*, Kerr., was reported (in error) as an injurious insect in the Punjab but is rarely found in North-West India. It appears to be a genus characteristic of sandy desert areas.

Chrysochroa includes 17 Indian species, of which *C. mutabilis*, Oliv., is found in the plains. This is a metallic green insect with red reflections especially at the margin of the elytra. *C. chinensis*, C. & G., is the beautiful green and red beetle sold as a curiosity in the hills and very common in some forest localities, while *C. edwardsii*, Ho., is the big yellow-blotched species abundant in the Khasi hills and also a source of income to the Khasi insect collector.

Psiloptera cupreosplendens, Saund., is occasionally caught in the plains, a smaller green and red metallic insect, the elytra much punctured.

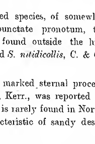


Fig. 208.—CHRYSOCHROA CHINENSIS.

Sphenoptera is the most abundant in cultivated areas, several species being found breeding in wild or cultivated plants. They are deep metallic bronzy insects, not of large size and by no means easy to discriminate. Kerremanns gives 20 Indian species. *S. gossypii*, Kerr. (Plate XX), is the cotton stem borer of the cotton areas, apparently widespread over India, and, as a rule, very common but only once found in

Behar. Its life-history is elsewhere described (Indian Insect Pests, p. 100). Another *Sphenoptera* is a serious enemy to groundnut (*Arachis hypogea*), the larvæ boring in the underground rootstock. It is abundant in South India. *Belionota prasina*., Thunb., is found boring in guava and mango trunks and is found commonly. It is a very dark metallic blue-black, the pronotum with a lateral indentation and red blotch, the elytra with four fine longitudinal ridges.

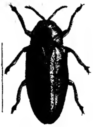


Fig. 209.—BELIONOTA PRASINA.

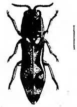


Fig. 210.—AGRILUS GRISATOR.

Kerremanns lists nearly 1,100 species of *Agrilus*, 38 of which are Indian. A species that is probably *A. grisator*, Kerr., has been reared from lemon trees and another species breeds in the same plant. They are small linear beetles of varied colouring.

Finally, we have the still smaller, more oval forms included in *Trachys*, 41 out of 260 of which Kerremanns records as Indian. So far as is known, the larvæ of these beetles are leaf miners and one has been reared from the leaves of Jute, another from Beal. Several species are common.

THROSCIDÆ.

Represented by *Throscus* (Trixagus) *proprius*, Bonv., found in North India.

EUCNEMIDÆ.

Twelve species are recorded from different localities in the hills.

ELATERIDÆ.—*Click Beetles.*

The hind angles of the thorax usually produced backwards. A prosternal process received in the mesosternum. Antennæ often serrate or pectinate.

A very large family of small or large beetles recognizable usually at sight from the very striking general facies peculiar to the family. The large forms, which are half an inch and more in length, are in many cases brightly coloured, the small forms, of which there are a great number, in dull tints of brown or yellow. The antennæ are moderately long and of varied form. The head is small and embedded in the solid prothorax. The prothorax is remarkably large and powerful, fitting loosely but accurately to the elytra, the lateral angles prolonged backwards. On the ventral surface is a process, which passes into the mesosternum in which is a cavity fitted to it. The abdomen is long, covered by the hard elytra; the legs are moderately long and formed for running. The striking structure of the prothorax is associated with the faculty many of the beetles have of leaping up with a click when placed on a flat surface with the venter upwards.

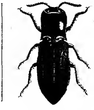


Fig. 211.—AGRYPNUS FUSCIPES.

Although these beetles are common everywhere in India, and there is an abundance of species, practically nothing is actually on record as to the life-history. We figure from Westwood a larva possibly that of *Agrypnus fuscipes*, the commonest large *Elaterid* of India. We are not aware that any species has actually been reared, though larvæ that are probably of this family can be found commonly enough. The known

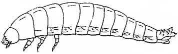


Fig. 212.—LARVA OF AGRYPNUS FUSCIPES. (*From Westwood.*)

larvæ elsewhere are cylindrical and elongated, the segments smooth and fitting closely to one another, the whole head and body forming a smooth flexible cylinder. There are three pairs of legs, and the hind end terminates in hooks and chitinised processes which probably give the larva leverage on the soil or other medium in which it lives and facilitates rapid locomotion.

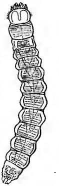


Fig. 213.—LARVA OF ALAUS OCULATUS. (*After Chapuis.*)

On the analogy of known European forms there can be no doubt that these brown shiny larvæ are those of *Elateridæ* but the difficulty is to rear them. It is uncertain whether they feed on roots or other vegetable matter or whether they are predaceous on other insects and so on those which really injure the roots of plants (e.g., *Melolonthidæ*). They are associated with damage to roots but may not cause it, and we are not aware of any instances of damage to roots by Elaterids in India. In the known species, the development is slow and several years are occupied in the metamorphosis. Nothing is known as to their enemies. none are known to be pests in India, and there are as yet no data as to their hibernation or seasonal occurrence. save the very general observation that. like most insects. they are found most abundantly in the rainy season.

The family is so large and complex that the preliminary difficulty of identifying or even separating the distinct species is at present insuperable. Practically all the known Indian species were described by Candeze. whose works must be consulted. Schwarz has listed the *Elateridæ*. as apart from the *Eucnemidæ*. etc.. in Genera Insectorum (1906). enumerating 503 species as occurring in India and Burmah alone. This cannot be more than a part of the actual species and new species are found in quantity.

Of the 28 sub-families. 21 are represented by Indian forms. The light-emitting *Pyrophorini* are confined to the new world and do not occur in India. *Agrypnus* (13 spp.) includes the large forms. *A. fuscipes*, Fabr. (fig. 210), being the common large black click-beetle of the plains. *Lacon* (44 spp.) is a common genus, with several plains species, smaller forms, with somewhat expanded prothorax. *Campsosternus* (30 spp.) are large insects of metallic colouring, usually green, abundant in hill forests and of striking appearance. The extremely common small click-beetles which come so abundantly to light in the plains during the rainy months are species of *Heteroderes* (16 spp.): nothing is yet known of their life-history or habits, in spite of the numbers in which they occur; they are wholly nocturnal, the beetles found by day in hiding on plants, in bark, under dry leaves, etc. *Cardiophorus* (75 spp.) is widely spread over the plains and abundant; *C. stolatus*, Er. is a small beetle, the elytra chestnut with a black fascia, also very abundant at light. *Cardiophorus quadrimaculatus*, Motsch., has yellow blotches on the elytra and is conspicuous. *Melanotus* (23) includes larger dark brown species, *M. fuscus*, Latr., common in Kanara and the hills, other species occurring in the plains. *Penia eschscholtzi*, Cost., is a broader rounder beetle of a bright brown colour with ochreous fasciæ, common in the Himalayas. *Plectrosternus rufus*, Lac., is the large red beetle with black longitudinal grooves, in which the prothorax is small and the antennæ conspicuously serrate. *Hemiops crassa*, Gylh., is smaller, the ground colour yellow but equally conspicuously coloured.

DICRONYCHIDÆ.

These are separated as a distinct family by Schwarz on account of the absence of penis. Two species of *Dicronychus* occur in India, of which *D. cinnamomeus*, Cand., is not uncommon in the plains, a small brown beetle with the typical facies of the *Elateridæ*.

CEBRIONIDÆ.

A single species is described as Indian, *Sandalus orientalis*, Bourg.

HETEROMERA.

A distinct series of beetles, whose classification into families is not clear. Four families are easily distinguishable as far as Indian forms are concerned.

Tenebrionidæ include a large number of the species, the tarsi not lobed, the claws smooth, the body compact with close fitting elytra.

Mordellidæ have the head peculiarly formed and inflexed, the hind coxæ with sharp plates.

Cantharidæ have the head with a neck, the tarsal claws with appendages, and the elytra not fitting the abdomen closely.

Trictenotomidæ are large, with long antennæ often serrate at the tip, long curved mandibles and resemble *Cerambycidæ*.

The remaining eleven families are of less importance and less easily recognisable. For papers on this group, see Fairmaire's papers on the Kurseong and Andrewes' collections (Ann. Soc. Ent., Belge, 1894, p. 17 ; 1896, p. 6).

TENEBRIONIDÆ.

Antennæ of eleven joints, under a projection of the side of the head. Tarsi heteromerous, simple. Abdomen of five segments.

A large family of beetles generally of sombre colour, found most abundantly in deserts and dry places. They are of moderate size, many of some bulk and weight. The antennæ are short and of varied form: the trophi are of the biting herbivorous type. The body is hard, often flattened, often globular, the elytra fitting closely and in the apterous forms soldered together. Sexual differences occur in a few, as in the erect horns on the head, the dilation of the tarsi, or the presence of the tuft of hair on the abdomen of the males.

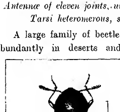


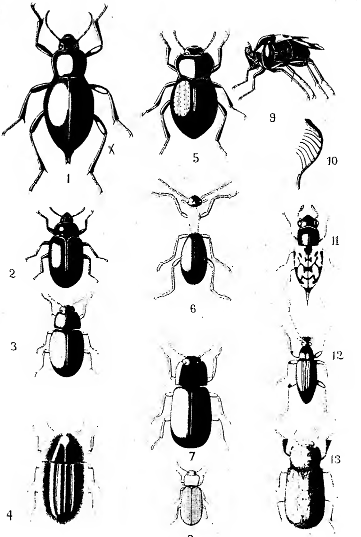
Fig. 214.—OPATRUM DEPRESSUM. [I. M. N.]

Little is known of the life-history and but few species have been reared in India. The larvæ are elongate, cylindrical, the segments with brown thickened integument: the hind end bears often two dorsal hooks and a ventral retractile process; the legs are present and functional in running. The larvæ are extremely difficult to find; *Opatrum* is in some places found literally in millions but its larva never: larvæ have been obtained first in captivity and then in the field only after prolonged searching. The known larvæ, like the known beetles, feed on dead vegetable matter such as decaying leaves; this also appears to be their food in desert places where there is a layer of leaves below each bush; we have seen these desert forms come out in numbers and feed on locust hoppers. The function of the family essentially is that of scavenging the dead vegetable matter that falls in such abundance and, excluding the household pests, none are injurious. The prevalence of deep black as a colour is to be expected since they are insects which shun light and which live in dark places where they are well hidden; the colouring strikes one when one sees these beetles in sandy deserts as in North India, but the colouration is of use since the beetles rapidly recover from the torpidity due to the chill of the air at night by coming out into the sunlight at sunrise for a short time before going into the bushes to feed. These beetles are a striking feature of the sandy wastes of North India where insect life is so scanty and these species are very imperfectly known and probably peculiar to such localities. Not all Tenebrionids live on the soil in concealment, though most do so: they really fall into two series, the light-seeking and the light-shunning species, the latter predominating. They are found among decaying vegetation, among fallen leaves, under bark, in thatched roofs, between the timbers of a house and generally in concealment. Practically nothing is known as to the length of their life-histories or their seasons; a yearly feature is the emergence of numbers of the very common beetle *Mesomorpha villiger*, which breeds in dry leaves and wood and which emerges abundantly to fly in the warm evenings in March in the plains. In the warm winter of 1907, these beetles emerged on February 25th, an exceptionally early date. *Opatrum* appears to have no season, nor do most of those which we have found abundantly in the plains, though *Blaps* is found only in the cold weather and probably has a yearly period.

The family is a very large one with a great number of species. The geographical distribution is wide, but the ground species appear to be most abundant in Africa, the Mediterranean and Caspian littoral, and

PLATE XXI.—HETEROMERA.

Fig. 1.	Blaps orientalis.	x $1\frac{1}{4}$.
,, 2.	Ceropria induta.	x 3.
,, 3.	Mesomorpha villiger.	x 4.
,, 4.	Cossyphus depressus	x 3.
,, 5.	Platynotus perforatus.	x $1\frac{1}{2}$.
,, 6.	Formicomus sp.	x 8.
,, 7.	Opatrum elongatum.	x 4.
,, 8.	Doliema plana.	x 4.
,, 9.	Emenadia ferruginea.	x $2\frac{1}{2}$.
,, 10.	,, ,,	male antenna.
,, 11.	Othnius delusus	x 7.
,, 12.	Allecula sp.	x 2.
,, 13.	Scleron orientale.	x 4.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in certain centres in the New World. India possesses but a small number of the large total of species and but few come into our plains fauna.

About 300 Indian species are recorded, of which perhaps fifty are found in the plains. The individual species are difficult to discriminate and no comprehensive work on the Indian species is in existence. The Cardon and Andrewes collections have been described (Ann. Soc. Ent.. Belge, 1894, 1896) and a number of species added lately, but the literature is scattered and the family requires revision. We are not aware of any records of life-histories or habits.

Polposipus herculeanus, Sol. is a large species covered with hair, whose characters are so odd that Lacordaire states that he thought the original describer might have had before him a "faked" insect, the head, legs and body belonging to three distinct genera. *Tenebrio* contains *T. molitor*, whose larva is so common in meal and flour and which is bred in large numbers as food for cage birds. It is now cosmopolitan. *Rhytinota*, *Pachycera*, *Hyperops* and *Himatismus* include rather elongate beetles of a dead black colour and small size, found sometimes in great abundance. The beetles have been collected at all times of the year and seem to have no distinct seasons. *Blaps* is the large "black beetle" of the plains, with *B. orientalis*, Sol. (Plate XXI, fig. 1), common and *B. indicola*, Bot.. rarer. The former is very common and striking; the elytra are soldered together and. in the females. produced into a process behind. which varies much in length. This beetle on being handled exudes an unpleasant liquid which stains a permanent dull red. Nothing appears to be known as to its life-history and all our specimens were captured between December and May. *Platynotus perforatus*. Muls. (Plate XXI. fig. 5). is also very common. a flatter beetle. more distinctly punctured. *Scleron denticolle*. Fairm.. and *S. orientale*. F. (Plate XXI. fig. 13). are small retiring beetles. characterised by the curiously flattened and expanded fore-femur and tibia. apparently for the purpose of digging.

Opatrum is perhaps the commonest of all the genera. occurring sometimes in enormous numbers. There are a variety of species. including *O. elongatum*, Guer. (Plate XXI. fig. 7). which is narrower and has the prothorax slightly tuberculate. *O. dorsogranosum*. Fairm..

in which the upper surface is somewhat granulose, and *Opatrum depressum*, Fabr., which is figured here. These species occur sometimes in incredible numbers; we have seen a field of six-foot-high indigo so infested that every stem was black; the beetles always shun light and in the dense indigo crop they live in shade and feed on the abundant dry leaves that fall. When the crop is cut they are brought in with it to the vats and sometimes cover the surrounding masonry, etc. A number of beetles were confined in the insectary and fed on these leaves; larvæ were eventually found which were reared without difficulty but which lived wholly on the surface of the soil under the covering of leaves. On first seeing the multitudes of these beetles that exist, one is tempted to wonder where their larvæ could have been: we realise it after having reared them and it is possible then to dimly see how vast may be the fauna hidden away like this on the soil and how important their work of disposing of plant refuse is. *Opatrum* apparently like most of its family, is wholly a feeder on dead or decaying vegetable tissue and the beetles have been found to even eat planks laid on the soil.

The genus *Toxicum* is marked by the erect horns of the males: these beetles are found under bark; the function of the horns is unknown. The two species of *Tribolium* occur widely spread, *T. ferrugineum*, Fabr., *T. confusus*, Duv. Both are pests of stored produce and occur frequently in dried insect collections. The latter is stated to be abundant in America, but we have been unable to recognise it in our long series. We reproduce the figures illustrating the differences in the two species in Chittenden's paper (U. S. Dept. of Agri. Ento. Bull., N. S. 4). It is, however, recorded from rice in Rangoon

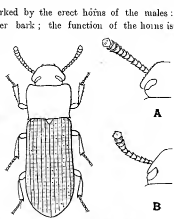

Fig. 215.—TRIBOLIUM CONFUSUM, A. HEAD OF T. CONFUSUS, B. FERRUGINEUM. (*After Chittenden.*)

(Indian Mus. Notes V, 139). The former is common and has been reared from wheat grains, wheat flour, and oat meal, as well as dried insects.

One of the more striking insects of the plains is the curious flattened *Cossyphus depressus*, Fabr. (Plate XXI, fig. 4), in which the elytra and pronotum are produced into a curved thin lamella surrounding the body after the manner of a Cassid beetle. What object this serves is uncertain, but it may give it a resemblance to a seed which is of use as a protection. *Derosphærus nigricollis*, Bot., is a larger beetle, the elytra deeply punctate and shining, with long legs, which is found on the soil in the plains. *Platydema* includes small oval brown beetles found eating the inner portions of the flakes of tree bark. *Mesomorpha villiger*, Bl. (Plate XXI, fig. 3), is a cosmopolitan beetle found among decaying leaves, in thatched roofs, in old trees, wherever there is decaying vegetable matter. It is a small dull brown or black beetle, rarely seen or noticed, but probably to be found everywhere if searched for. *Ceropria* (Plate XXI, fig. 2) includes a few brightly coloured species with tints of shiny purple or blue.

Collecting, etc.—It is probable that only a small part of the Tenebrionid fauna of our area is actually recorded, and the collector will find much that is new. These beetles can be easily kept in captivity and breeding experiments are required to determine life-histories, etc., with much field observation. The beetles themselves are not difficult to find under bark, amongst fallen leaves, in thatched roofs, among cut timber and in similar situations. The Desert fauna of North India especially requires investigation and much interesting work waits to be done on the life-histories and habits of these species.

CISTELIDÆ.

Characters as in the previous family but the tarsal claws pectinate, not simple.

A small family of unimportant beetles, rarely found. They have long antennæ; the elytra do not fit the abdomen very closely: the males have longer antennæ and larger eyes than the females. In a few the head is prolonged into a distinct short blunt rostrum. The known species live in decaying trees or under bark, as do their larvæ.

About thirty species are Indian, including *Allecula* (Plate XXI, fig. 12), *Cistela* and *Cistelomorpha*.

LAGRIIDÆ.

Anterior coxæ projecting, conical and contiguous. Anterior coxal cavities closed behind; claws simple, ventral segments five, penultimate tarsal joint bilobed and pubescent.

These are Tenebrionids with different coxæ and having anterior coxal cavities closed behind, and will not, by the close coleopterous student, be confused with other *Heteromera*.

About forty species are described from India alone; *Lagria* is the most important genus, widespread and with several common Indian species; the body is hairy, the head has a thick neck, the tarsus has the penultimate joint expanded and pubescent as in the *Chrysomelidæ*.

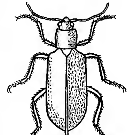
Fig. 216.—LAGRIA SP. × 2.

OTHNIIDÆ.

This family is represented in India by a small species. *Othnius delusus*, Pasc. (Plate XXI, fig. 11), found in the hills of South India.

MONOMMIDÆ.

Represented in India by a single species, *Monomma brunneum*. Thoms. (fig. 216), found under the bark of trees. This is a dark

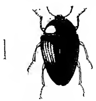
Fig. 217.—MONOMMA BRUNNEUM.

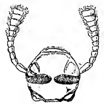
Fig. 218.—HEAD OF M. GIGANTEUM. (*From Thomson.*)

brown insect, with clubbed antennæ fitting into grooves of the lower side of the prothorax. The group is monographed by Thomson (Ann. Soc. Ent., France, 1860).

PYTHIDÆ.

Anterior coxal cavities open behind (c.f. *Tenebrionidæ*). *Prothorax narrower at the base than the elytra. Eyes entire.*

A small family of unimportant insects separated on minute characters from its allies. The family is small with few representatives. None are common in the plains, and *Doliema plana*, Fabr. (Plate XXI, fig. 8), is the species most likely to be found.

MELANDRYIDÆ.

A family distinct from all allies by a variety of characters: the claws are not pectinate (*Cistelidæ*), the anterior coxal cavities are open behind (*Tenebrionids*); they are not hemispherical (*Nilionidæ*): the prothorax is as broad as the elytra (*Pythidæ*); there is no neck (*Mordellides*); and finally the pronotum does not extend laterally on the prothorax (rest of Heteromera).

So far as our fauna is concerned they are of no importance whatever: They are dull coloured insects found in decaying wood in temperate regions. *Penthe rufopubens*, Mors., has been described as Indian.

PYROCHROIDÆ.

Antennæ flabellate or pectinate. Prothorax narrower than the elytra. Head with a neck. Elytra longer than the body. Penultimate tarsal joint broadened.

Beetles of small to moderate size, found with their larvæ under the bark of trees. *Pyrochroa* is the common genus, with the antennæ toothed (or nearly pectinate in the males), the body finely pubescent. Three species have been described, *P. deplanata*, Pic., from Malabar, *P. subcostulata*, Fairm., from Cashmere, and *P. cardoni*, Fairm., from the Himalayas (North Bengal).

ANTHICIDÆ.

Head with a neck. Antennæ filiform. Prothorax narrower at the base than the elytra. Claws simple.

This family includes four sub-families recognised by many authors as families. The *Pedilinæ* include less than ten species of *Macrataria*.

Anthicinæ.—These are small slender beetles with a distinct resemblance to ants, common in grass, and sometimes very abundant. They are to be found running actively on grass and plants just as ants do, and they appear to be predaceous on small insects and Aphides. Nothing is known of their life-history.

Mons. Maindron obtained 19 species during his tour in India (Ann. Soc. Ent., France, 1903, p. 348). Laferte monographed the *Anthicinæ* in 1848, listing 31 species of *Anthicus*. Cardon's collections are described by Fairmaire and Pic (Ann. Soc. Ent., Belge, 1894). *Formicomus* (19 species) and *Anthicus* (62 species) include the species found in the plains (Plate XXI, fig. 6).

Hylophilinæ.—Small beetles, less than one-eighth of an inch long with the basal two abdominal segments united and four segments beyond free. Basal tarsal segment long, penultimate bilobed. These small beetles are but little known and their life-histories scarcely at all. They are stated to live in dead wood. None have been reared in India and only a few collected.

The most recent monograph (M. Pic. Ann. Soc. Ent., France, 1906, p. 190) records *Hylobænus indicus*, Pic., and eight species of *Hylophilus* as Indian.

Scraptiinæ.—*Scroptia pulicaria*, Fairm., is the sole recorded species.

ŒDEMERIDÆ.

Head narrowed behind, produced in front into a short rostrum. Antennæ usually filiform, eleven or twelve jointed. Prothorax narrower than the elytra. Penultimate tarsal joint bilobed.

These are somewhat elongate beetles, of thin integument, found on flowers or decaying wood, some diurnal, some nocturnal. So far as known, the larvæ are feeders in or on wood or decaying timber and are occasionally injurious. The beetles resemble Longicorns on the one hand, or Malacodermids on the other. Five species are described by Fairmaire with *Asclera indica*, from Bengal, and *Oncomera* (Dryops) *indica* from Kanara.

MORDELLIDÆ.

Head short, bent down over the legs, with a narrow neck, antennæ filiform, dentate or, in the males, pectinate.

Small thickset short beetles with, in our common species, a characteristic facies. They fall into two series, partly regarded as distinct families (*Rhipiphorinæ* and *Mordellinæ*). Our common species belong to the former and, so far as known, are parasites in the nests of Aculeate Hymenoptera. Horne figures *Emenadia ferruginea*, F. (*flabellata*, F.), which he reared from the nests of *Eumenes* in India. This and other species are common on the wing in the plains and are readily recognisable: the elytra are pointed, the body very thickset, vertical in front, the colouring black and yellow brown (Plate XXI, figs. 9, 10). This genus is practically world-wide. *Rhipiphorus pectinicornis*, Thunb. (*blattarum*, Saund.), is parasitic, the female wingless and larviform, living on cockroaches. Of the two genera, nine are recorded as Indian. Of the *Mordellinæ*, none appear to be recorded: we have reared one species from larvæ found boring in the stems of *Dicliptera*.

CANTHARIDÆ.—*Blister Beetles.*

The head is joined to the prothorax by a distinct neck. The elytra are not closely applied to the abdomen: the integument is weak. The claws have appendages.

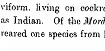

Fig. 219.—MYLABRIS PUSTULATA.

These beetles are easily recognisable from the above characters and have a distinct facies. They are rarely over one inch long, usually about half an inch, moderately robustly built. The colours are varied, in some cases typically warning, in others blue, brown or dull coloured. The antennæ are long and simple, rarely of less joints than eleven in the *Mylabrinæ*: the head is of moderate size, the compound eyes large, the biting mouth-parts not conspicuous. The prothorax is narrower than the head and the two are not broadly united but joined by a neck

The elytra neither meet accurately in the median line nor fit closely to the side of the abdomen and only loosely cover the upper surface of the body. The wings are ample and used in flight; *Melæ* is wingless with abbreviated elytra. The legs are long, the tarsi long, the claws with a closely fitting appendage below, which resembles a duplicate claw. Males are similar to females but smaller; size is often very variable in both sexes. An acrid oil is excreted from openings in the apices of the femora in *Mylabris*, *Cantharis* and *Melæ*; this oil contains an active principle, Cantharidin, which has irritant properties rendering it commercially valuable.

Almost nothing is known of the life-history of Indian species. Large masses of small yellow eggs are deposited on grass or soil, from which hatch small active larvæ of the usual Coleopterous form. The further history of these larvæ has not been traced. The student should consult the account of the life-history of the known species of *Melæ* and *Epicauta*, details of which are given in Sharp's Insects. These insects are parasitic upon the larvæ of Aculeate *Hymenoptera* or upon the egg masses of *Acridiidæ*.

The beetles are diurnal, the winged species flying readily. They are herbivorous, feeding on leaves and flowers and, when abundant, form a conspicuous part of the diurnal fauna. Each species appears yearly and there is but one brood. They are often very abundant and occasionally appear in large numbers with great suddenness and in an apparently mysterious fashion. Owing to their herbivorous habits and frequent abundance, the beetles may be injurious to cultivated plants. The flower-eating species of *Epicauta* (*Cantharis*) destroy the anthers and pistils of cereals and thus cause serious damage to the crops. The latter form of damage is of frequent occurrence, *Andropogon sorghum* (juar, great millet) being specially affected. (Compare the habits of *Chiloloba*, the *Cetoniid* beetle.) *Cantharis hirticornis*, Haag, is destructive to *Amaranthus* and vegetables in Assam, the beetles being abundant in May and devouring the leaves.

The family is a large one, found principally in the tropics. Over 70 Indian species are described and less than ten are common in the plains, these being apparently widely spread over the Indian region. There are four principal genera, *Cantharis* (*Epicauta*), *Mylabris*, *Zonitis*, which are winged, and the wingless *Meloe*. There is considerable confusion in the nomenclature of the recorded species, and the specific names adopted here are liable to revision when the nomenclature of the family is revised.

Meloinæ.—Wingless. Metasternum very short, middle coxæ covering the hind coxæ. *Meloe* is the important genus, of which 2 Indian species are recorded.

Mylabrinæ.—*Mylabris* is winged but has the antennæ short, curved and thick. Marseul monographed the sub-family in 1873 (Mem. Soc., Liege (2) III, pp. 363—662).

The common form is *Mylabris pustulata*, Thunb., doubtfully distinct from *M. sidæ*. *M. rouxi*, Cast., is a similar but smaller, black and yellow species, while 16 other species are recorded.

M. pustulata, Thunb., is a conspicuous beetle, measuring about one inch in length, coloured black with large orange marks on the wings and prothorax. The wings and body are softer than in many beetles, the typical head and antennæ are those characteristic of the *Cantharidæ*, and the yellow fluid exuding from the joints of the legs further characterises this common insect. The life-history is unknown, and the life-histories of those *Cantharidæ* which have been studied are so various that there is no indication as to what the life-history of this insect is likely to be. The fluid exuded from the joints of the legs, with its blistering properties and probably unpleasant flavour, serves as a protection from birds and other enemies; the colouration is that known as "warning," that is, it serves to plainly advertise the unpleasant nature of this insect, so that birds, etc., may not eat it. In its habits this insect is, as would be expected, conspicuous: it may be seen on plants, fully exposed, so that its warning livery is clearly seen. It feeds upon the flowers of plants, notably *Cucurbitaceæ* such as the melon, pumpkin, cucumber, white gourd, etc. It is common in the plains and occurs throughout India where vegetation is abundant. There is one brood in the year and these beetles appear sometimes in great numbers and are very destructive.

Cantharinæ.—The antennæ longer, not curved, filiform. *Cantharis* (Epicauta) contains a number of common species of which little is as yet known. *C. violacea*, Makl., is a small deep-blue form found in Western India. *C. actæon*, Cast., is the very common large blue species, found for a short time in the rains. *C. tenuicollis*, Pall. (? *C. ruficollis*, Pall., *C. ornata*, Cast.), is a green form with a slender reddish prothorax, which, with the dull brown *C. rouxi*, Cast., is destructive to cereals by devouring the stigma and anthers, no grain being formed. When the flowering of rice, millets or juar coincides with the emergence of these beetles, widespread loss may occur. *C. hirticornis*, Haag., is a black species with red head found abundantly in Assam in May where it feeds on Amaranthus and other vegetables. *Illetica testacea*, Fabr., is the more robust and densely chitinised red-brown species found in the rains. This has robust mandibles; the shiny black thorax and lined elytra are hard and strong, giving the beetle more the appearance of a *Cerambycid*.

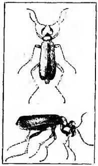
Fig. 220.—CANTHARIS TENUICOLLIS.

Cissites Debyi.—Green has observed that the eggs of this species are laid in the galleries of *Xylocopa tenuiscapa*, Westw., in Ceylon; some of the larvæ, he imagines, migrate on the bees to other colonies. (? *viâ* the flowers visited by the bees) and those that remain in the original nest (and presumably attack the bee-larvæ) pupate in side tunnels which they make off the main bee-tunnel (Ent. Mo. Mag., 1902, 232).

COLLECTING.

Collecting.—The beetles are readily captured with the hand and require to be carefully dried. They lay eggs freely in captivity, the eggs hatch and, in captivity, nothing further can happen. The further elucidation of the life-history requires either the extremely careful observation of the larvæ when hatched in the open or prolonged investigation into the egg masses of *Acridiids* or the nests of Aculeate *Hymenoptera* in the hope of finding larvæ. Any opportunity of doing either should be seized, as no progress can be made till more is known and we can at present only estimate their directly injurious effect as adults.

TRICTENOTOMIDÆ.

Antennæ long, serrate inside at the apex. Tarsi heteromerous.

These are large beetles, practically heteromerous Longicornia with slightly serrate antennæ. They have long bodies, the dark colours (except *Autocrates ænea*, Westw., which is metallic blue), the general facies of many Cerambycid beetles and are found in the same habitat. These insects are characteristic of the Indo-Malayan region, particularly of forest areas.

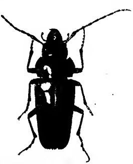

FIG. 221.—TRICTENOTOMA CHILDRENI, × 1.

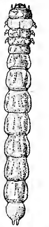

FIG. 222.—TRICTENOTOMA CHILDRENI LARVA. (*After Gahan*).

Autocrates has the prothorax spined, the scutellum blunt. *Trictenotoma* has the prothorax only angulated, scutellum longer and sharper. Very little is known of the life-history of these insects : they are probably predaceous in the adult stage. The larva of *T. childreni* has recently been described and figured by Gahan from Java specimens (Trans. Ent. Soc., London. 1908, p. 275) ; we reproduce one figure in the hope that it may assist in the recognition of larvæ of this family in South

India where they must occur. The structure of the larvæ is held to support the view that this family is more nearly related to the *Pythidæ* or *Pyrochroidæ* than to any other *Heteromera*. Besides the metallic blue *Autocrates ænea*, Westw., of the Himalayas, *Trictenotoma Grayi*, Sm., occurs in South India, *T. childreni*, Gray, in the Khasis, and *T. mniszechi*, Deyr., in the Himalayas (Ann. Soc. Ent., France, 1875, p. LIX). Westwood (Cab. Or. Entom., 1847) figures *T. childreni*, Gray, *T. templetonii*, Westw., and *T. ænea*, Parry, and discusses the characters on which he separates these as a distinct family.

PHYTOPHAGA.

The tendency in classification at present is to a complexity of families, especially in *Coleoptera*, and while this is possibly justified from structural characters, it is certain that there is not as yet sufficient material available to define so many families; to all but the student of systematic entomology, the old broad families embracing insects allied in structure and habits are still the most natural and the simplest in actual working. We have accordingly adhered to the three families composing this series, the plant-feeding beetles; the Bruchids are seed-eating, the Chrysomelids live on green plants, the Cerambycids in the woody tissues of plants. This makes but three families and to place an insect in one of these three, places it as far as these habits go. Modern classification makes two or more of Bruchids, 13 or more of Chrysomelids, and two of Cerambycids, with a great tendency to make more.

The series is distinguished by the apparently four-jointed tarsi usually with at least one joint expanded and pubescent beneath, and the absence of a prolongation of the head as a rostrum. It is, in practice in the field, a peculiarly homogeneous series, the three families sharply distinct in all our common species. It is easy to put a *Sclerodonta* down as a weevil however, though it has no distinct beak, because it resembles the leaf-eating smaller weevils in which the rostrum is not much developed and actually the limits of these two series do, as they should, shade into each other.

BRUCHIDÆ.—*Pulse Beetles.*

Small thickset beetles, the hind legs thickened, the prosternum vertical. Tarsi apparently four-jointed, pilose below, third joint bilobed. Antennæ eleven-jointed, often dentate or pectinate.

These small beetles have a characteristic facies which distinguishes them from other *Phytophaga*, but confuses them with *Anthribidæ*. They are small, rarely exceeding one-quarter of an inch in length. Their colours are sombre and inconspicuous, the body clothed with hairs. The head is small with a blunt rostrum, with short antennæ, often pectinate or serrate. The prothorax is well developed and accurately adapted to the mesothorax. The elytra are truncate, not covering the pygidium. The legs are short, the hind femora thickened. The abdomen is peculiarly thickset, giving the beetles a characteristic appearance.

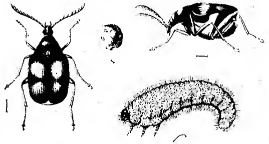

Fig. 223.—BRUCHUS CHINENSIS; EGG ON PEA, × 2; LARVA, × 12; IMAGO, × 10.

These beetles are commonly reared from the seeds of leguminous plants. The beetle lays a number of small oval eggs, of a yellow colour; they are apparently laid in a semi-liquid condition, so that they adhere to the seed or pod and then harden. (they have a curious resemblance to Scale insects of the genus *Asterolecanium*). In the field they are laid in the pod and in the case of *Bruchus obtectus*, Say, they are often dropped loosely among the seeds (Chittenden). These eggs hatch, the larva eating through the inner wall of the egg-shell into the seed-coat and so into the seed itself where it feeds upon the tissues. The larva is white, curved and with a close resemblance to larvæ of weevils. Riley showed that, in the first instar, the larva is provided with three pairs of incomplete but functional legs, as well as a series of thoracic spines and a pair of toothed thoracic plates which enable the larva to bore into the pod or seed and so establish itself. When it has reached the seed, it moults and appears without the legs and the thoracic plates. As a rule, one seed, if full grown, is sufficient for a larva (or for many), but in the case of growing seeds the larva may eat so fast that the seed cannot develop and it has to move into a fresh one. When full grown, the larva cuts a disc in the seed-coat almost through and pupates below. When the beetle is ready to emerge, the disc readily opens, letting out the perfect insect. In *Caryoborus gonagra* the larva comes out of the seed and pupates outside in an excrementitious cocoon. The beetles are found in the field visiting flowers of leguminous plants or on the leaves of plants. They appear to take no food, as do the household species also. There is no information available on the question of the hibernation, etc., of the free-living species. None are pests to crops in India but the household species are destructive to stored pulse. Bruchid larvæ are the hosts of Chalcid parasites, which lay their eggs in the larvæ in the seeds. These insects are sometimes found in abundance in infested pulse.

The family is not a large one and, with the exception of the cosmopolitan household species, is principally found in the tropics. No list of Indian species exists and there is room for work on this family. Including cosmopolitan insects, 37 species are known from India and the number of species recorded from the plains is a very small proportion of those there are. The family is divided into two tribes: *Urodontides* with clubbed antennæ represented by *Urodon* in Ceylon; *Bruchides* with dentate or pectinate flattened antennæ. The following six species of *Bruchus* include the known or recorded species found in stored pulse in India :—

(1) *B. chinensis*, Linn., in *Pisum sativum* (peas), *Dolichos lab-lab* (val), *Dolichos biflorus* (moth), *Cicer arietinum* (gram), *Cajanus indicus* (pigeon pea), *Ervum lens* (lentil), *Vigna catjang* (cow pea).

(2) *B. affinis*, Froll., in imported beans.
(3) *B. emarginatus*, All., in peas (*Pisum sativum*).
(4) *B. quadrimaculatus*, Fabr., in peas (*Pisum sativum*) and in "beans."
(5) *B. pisorum*, Linn., in peas (*Pisum sativum*).
(6) *B analis*, Fabr., from cow pea (*Vigna catjang*).

Chittenden (Yearbook, Agric. Dept., U. S. A., 1898, p. 240) states that *B. obtectus*, Say, also occurs and it is likely to be found. The life-histories of *B. pisorum*, *B. chinensis*, *B. obtectus* and *B. quadrimaculatus*, are fully described by Chittenden (loc. cit.). Short accounts occur in most general works on entomology. We are not aware that any of these species have been reared in India, except from harvested seed; elsewhere the beetles lay eggs in the pods on the plant, as well as on the stored seeds, but we have seen no instance where Bruchids attacked any cultivated pulse in the field, though many other insects are known which do so. We may presume either that these cosmopolitan species originated elsewhere or, if native to India, breed in wild plants; a very small number of species have been bred from wild leguminous pods in India, and these species do not occur among them. We believe all our destructive Bruchids to have originated elsewhere.

Caryoborus gonagra, F., is a larger grey-brown insect, found in tamarind seeds and is the commonest free-living species in India. The larva when full grown emerges from the seed and prepares a cocoon of very coarse and gummy white threads, within which it pupates; this cocoon is oval and attached to some part of the seed or pod. The imago feeds on the leaves of the tamarind tree. The life-history was described in a German paper by Elditt in 1860, he having reared it from pods of *Cassia* obtained from India (Indian Mus. Notes, III, p. 15).

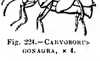

Fig. 224.—Caryoborus gonagra, × 4.

Chrysomelidæ. *Leaf-Eating Beetles.*

Antennæ moderately long, their insertion distinct from the eyes. Upper surface bare.

The *Chrysomelidæ* are readily distinguished as they are *Phytophaga* without long antennæ as in the *Cerambycidæ*, and without the

PLATE XXII.—GALERUCELLA RUGOSA.

Fig. 1. Eggs on leaf. x 3.
„ 2. Larva on leaf. x 3.
„ 3. „ 48 hours after hatching. x 20.
„ 4. „ full grown x 6.
„ 5. Pupa. x 8.
„ 6. Female. x 8.
„ 7. Male. x 8.

1

2

3

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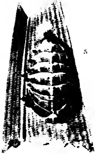

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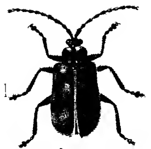

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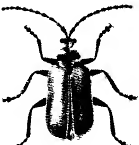

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peculiar form and hind legs of the *Bruchidæ*. They are also neither bred from pulse nor in trees and are on the whole a distinct and easily re-

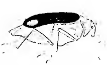


Fig. 225.—AULACOPHORA EXCAVATA, × 3.

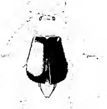


Fig. 226.—AULACOPHORA EXCAVATA, × 3.

cognised family. Individual species approximate on the one hand to the *Bruchidæ* and on the other to *Cerambycidæ*, and there is no really sharp line of distinction, but the very great majority are clearly recognisable. These beetles comprise a very large and varied assemblage, including a greater number and variety of forms than any other family of *Coleoptera*. All are herbivorous, the beetles are smooth, not being hairy as a rule or at least without the pubescent hairiness of Bruchids and Cerambycids. All are diurnal. It is impossible to discuss them as a whole and would serve no useful purpose; they are divisible into a large number of divisions, some of which are extremely characteristic and without going deeply into the dry details of classification, we can readily distinguish the more important of these.

There are first the *Eupoda*, in which the prothorax is much narrower at the base than the elytra. The *Camptosomes* have one distinctive character, the lines of the abdominal segments not going straight across but curving, making the middle of each segment narrower than the sides, and leaving a large space in the middle for the fifth.

The *Cyclica* have not the above characters, but the prothorax is often a little narrower than the elytra and usually has the edges distinct, not rounded off.

Finally the *Cryptostomes* are very characteristic, the head being bent down so that the mouth is below, the antennæ inserted close together at the front of the head. They include the very distinct *Cassidinæ* in which the head is hidden, and the *Hispinæ*, which have a characteristic outline and are often spiny. Actually if a Chrysomelid has not the narrow prothorax, nor the curved ventral abdominal sutures, nor the deflexed head and the contiguous antennæ, it must be one of the *Cyclica*, the largest division of this large family.

Prothorax narrowed, rounded. Head constricted behind eyes, produced anteriorly. *EUPODA*.	*Sagrinæ*. *Donaciinæ*. *Criocerinæ*.	
Ventral abdominal sutures curved. *CAMPTOSOMES*.	(Megascelinæ). *Megalopinæ*. *Clytrinæ*. *Cryptocephalinæ*. *Chlamynæ*. (Sphærocarinæ).	
Prothorax a little narrowed but laterally acute. *CYCLICA*.	(Lamprosominæ).	
	Antennæ separate.	Feet bilobed. *Eumolpinæ*. Feet simple. *Chrysomelinæ*.
	Antennæ approximate, elytra soft. *Galerucinæ*. (Trichostomes).	Posterior coxæ grooved. *Halticini*. Posterior coxæ not grooved. *Galerucini*.
Antennæ approximate Head deflexed. *CRYPTOSTOMES*.	Head exposed. *Hispinæ*. Head concealed. *Cassidinæ*.	

The following is a synopsis of the larval habits as far as they are known :—

Sagrinæ.—Roots of trees.

Donaciinæ.—In aquatic plants.

Criocerinæ.—On aquatic plants above water, or on land plants with excrement over.

Camptosomes.—In cases, on plants or in ants' nests.

Eumolpinæ.—In roots or in soil.

Chrysomelinæ.—Free, leaf-feeding.
Halticini.—Mining in leaf or plant, or tree.
Galerucini.—Free, exposed, or in underground parts of plants.
Hispinæ.—Mining.
Cassidinæ.—Exposed, carrying excrement or having anal process.

A great number of species have been described both in the older publications of Hope, Oliver, Illiger, Baly (Chennell's Assam Collection, etc.), and more recently by Jacoby, whose descriptions of the Cardon and Andrewes' collections add many new species (Ann. Soc. Ent., Belge, 1895, p. 252; 1897, p. 420; 1898, p. 185; 1903, p. 80: 1904, p. 380). The late Mr. Jacoby's volume of the Fauna of India deals with the family as far as *Eumolpinæ.*

Eupoda.—The *Sagrinæ* are the first sub-family, with five species of *Sagra* in India. These are characteristic insects, of large size and brilliant colouring, of which the life-history is almost wholly unknown. The oval brown cocoons of *S. boisduvallii* were found at Buitenzorg in the hollow root of a tree (Rhizophora) in 1862, (Nederl. Tijdschrift. V, p. 97), and it is known that in Java, *Sagra Buqueti* lays eggs on the bark of a tree, the larvæ living in the tree and causing gall-like hypertrophy of the wood. The beetles are found upon plants, *Sagra femorata,* Dy., a metallic green insect, being the common species in India, found in forests.

Donaciinæ are a small group, of which four species are Indian. The larvæ of *Donacia* live in aquatic plants, the beetles in water or in the air. None appear to have been reared in India. *Donacia æraria,* By., is found in the plains, though not commonly. *Hæmonia,* though not recorded as Indian, is also known from the plains.

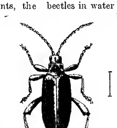


Fig. 227.—DONACIA RECTICOLLIS.

Criocerinæ.—A larger group with 105 Indian species of which 80 are included in *Lema* and 19 in *Crioceris.* The Ceylon forms are distinct and are treated by Jacoby as Malayo-Australian, only one occurring apparently also in South India.

The life-history of none of these is definitely recorded. *Crioceris impressa*, F., was reared by de Niceville on kham-alu (*Dioscorea alata*) (Indian Mus. Notes, V, p. 134). In general the larvæ are either semiaquatic, living on the leaves of aquatic plants in cases made of their own excrement, or live on plants on land in the same way. These larvæ have the anus on the upper surface so that as their excrement is voided, it covers the body and makes a protective covering. They are extremely characteristic in appearance and are likely to be found on aquatic plants. The beetles are common in grass and on plants: they are usually brightly coloured and warning; several species are common. *Lema coromandeliana*, F., and *Crioceris impressa*, F., being widely spread in the plains.

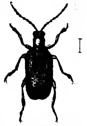


Fig. 228.—LEMA SIGNATIPENNIS.

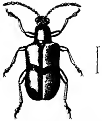


Fig. 229.—CRIOCERIS FASCIATIPENNIS.

Camptosomes.—A large division divided into several sub-families, some of which are not represented in India. The *Clytrinæ*, *Chlamynæ* and *Cryptocephalinæ*, are the most common, with many species of small cylindrical beetles, coloured often in orange or yellow and black. The larvæ of *Cryptocephalus* are of peculiar form and live in small cases formed of their excrement: they are white larvæ, with the abdomen tapering and doubled back under the body so that the apex reaches the thoracic legs; the case made is a small oval one, in which the **larva** lives with the head and thorax at the opening, the anus in such a position that the excreta can be ejected. (In a Himalayan species living on Artemisia, the cases very closely resemble the excreta of the larger grasshoppers and this is possibly a protective device.) The cases of *C. corrosicollis*, Jac., are common on long grass and those of *C. Pusaensis*, Jac., on "Jhau" (*Tamarix gallica*), and the little larvæ can be readily reared. Donnisthorpe has described the life-history of the European *Clythra quadri-punctata*, L., in Trans. Ent. Soc., London., 1902, p. 11. We reproduce his summary :—

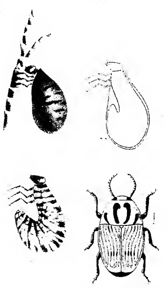


Fig. 230.—CRYPTOCEPHALUS PUSAENSIS. LARVA, IN AND OUT OF CASE, DIAGRAM OF CASE, IMAGO.

"To recapitulate the foregoing facts : The life-history of *Clythra quadri-punctata* is briefly as follows :—When the beetle has emerged from the pupa in the nest, it escapes with caution 'feigning death,' and holding on to twigs, when attacked by the ants. It then seeks its mate, and copulation takes place. The beetles are generally to be found on birch shrubs, the young shoots and leaves of which they eat, biting the top shoots right through. The female then seeks a tree or shrub above or close to a nest of Formica rufa, and drops the eggs on to the ground beneath. The eggs are covered by a case, or capsule, which is placed around it by the female, and consists of her own excrement. This covering is placed in position with the posterior tarsi, the egg being held in the depression of the abdomen. The covered egg looks exactly like a small bract, and is exceedingly like the end of a birch catkin. The ants pick up the covered egg and carry it into the nest. The young larva, which hatches in about twenty-one days, uses the egg-case as a nucleus on which to build the larval case; thus very young larval cases have the egg-case still attached to their posterior end. The egg-case has a threefold *raison d'être*—to protect the egg and newly hatched larva, to make the ants believe it is a bit of useful vegetable refuse, and to give the larva a foundation on which to start the larval case. When the larva case grows larger the egg-case breaks off and the larva fills up the hole thus formed with the same material as that with which it builds the rest of the case. This material consists of its own excrement mixed with earth, which it prepares with its mandibles. To enlarge the case the larva removes particles from the inside, and plasters them on to the outside. The larva feeds on vegetable refuse in the nest. When changing its skin it fastens the case to some object in the nest. When full-grown it fastens the case to a piece of wood or twig, and turning completely round, changes to a pupa, facing the broader end of the case. When hatched the beetle gets out of the case at this broader end, by biting a circle round inside it, thus forming a cap, which it forces off."

The student should refer to this account and read the bibliographical remarks especially. There is nothing to show that our species have this habit, but it is worth bearing in mind when searching ants' nests for insects.

The *Megalopinæ* include *Temnaspis* (4), and *Colobaspis* (4), rare insects found in the hills. The *Clytrinæ* are listed by Jacoby and

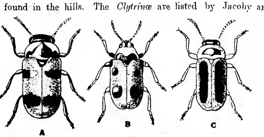


Fig. 231.—A. Diapromorpha pinguis, B. Aspidolopha thoracica. C. Gynandrophthalma subdivisa. (*After Jacoby.*)

Clavareau in Genera Insectorum, with 90 species from the Indian region of which less than fifteen are found in India proper. Jacoby describes 125 species in the Fauna of India. *Titubœa bimaculata*, Jac., *Clytra succincta*, Lac., *Clytra conformis*, Lac., *Coptocephala nair*, Lac., and *Diapromorpha turcica*, Fabr., appear to be common species of the *Clytrides*, and *Cryptocephalus senarius*, Suff., *Cryptocephalus schestedti*, Fabr., *Cryptocephalus corrosicollis*, Jac., among *Cryptocephalides*. Of the latter genus nearly fifty Indian species were recorded forty years ago and a larger number have been since described. *Exema*, *Chlamys* and *Hymetes* represent the *Chlamynæ*, which are almost wholly American.

Cyclica.—The largest division with the greatest number of species. There are three main sub-divisions of which two, *Eumolpinæ* and *Chrysomelinæ*, have the base of the antennæ separated widely, whilst the third, *Galerucinæ*, has the bases of the antennæ drawn together though not touching. The latter are separated by Jacoby under the term *Trichostomes*. In all, the beetles are of small to moderate size, usually brightly coloured. They constitute the immense majority of the family, the typical leaf-eating beetles. Colours are usually warning, bright blue, bright red, a great variety of tints.

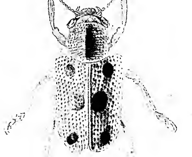


Fig. 232.—SCELODONTA STRIGICOLLIS.

Eumolpinæ.—Practically nothing is on record as to the life-histories of our forms, but the larvæ probably are miners in roots or live in the soil feeding on roots. Jacoby records 414 species from the Indian region. *Scelodonta* includes small dull coloured beetles found abundantly on grass and on plants. *S. strigicollis*, Mots., is common on grape vines and where this plant is cultivated, is a serious pest. The late Mr. Jacoby wrote in the Fauna that this species could no longer be recognised, but he labelled a series of specimens from the Pusa collection with this name and omitted to record the localities in the volume. (It will probably be found to have a similar life-history to its ally the American grape vine rootworm, *Fidia viticida*, whose life-history has been described.) *S. vittata* is a larger form, found on Panchanjuria (*Vitis trifolia*), which shams death extremely effectively and falls to the ground on its back, the brown lower surface and white patches making it very difficult to distinguish.

Colasposoma is a large genus of moderate-sized metallic-coloured beetles, *C. metallicus*, Clk. and *C. ornatum*, Jac., being common in the plains. *Corynodes peregrinum*, Fuesl., is a deep blue beetle, very abundant feeding on Ak and other wild plants and found throughout the plains. *Nodostoma*, *Nodina*, *Heteraspis*, *Pseudocolaspis*, *Colaspis* and *Colaspoides*, are the other common genera.

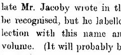


Fig. 233.—LARVA OF CORYNODES PEREGRINUS. × 6.

Pachnephorus bretinghami, Jac., and *P. impressus*, Ros., take the place in India that *Myochrous* takes in America, as being destructive to the young shoots of cane and cereals; they are small dust-coloured beetles, with the appearance of weevils, found in numbers in the expanding leaves of the young cane shoots which they destroy; hidden in the heart of the shoot, they are difficult to find and usually escape observation, the destruction of the young shoot being assigned to some other cause.

Chrysomelinæ.—Though these beetles occur in all parts of India, very little appears to be known beyond the mere description of such species as have reached European collections and been described. Nor is there any complete list at present available and the recorded Indian species are buried in a voluminous and scattered literature. It is the least represented division with less than 70 recorded species. We are not aware of any species being of economic importance to agriculture in India and the larvæ apparently feed wholly upon trees, uncultivated shrubs and herbs. The group is characteristic of the temperate regions and only a few come into our limits, the majority being Himalayan. A large number of larvæ of exotic species have been described and these are known to feed openly upon the leaves of plants as do the *Galerucinæ*. *Phædon brassicæ*, Baly., is a steel-blue beetle found feeding upon mustard in Golaghat (Indian Mus. Notes, Vol. III, p. 44). *Plagiodera* is represented by several species and *Lina* is represented by the European *L. populi*, Linn., which occurs in the Himalayas. *Chrysomela* includes a variety of moderate-sized beetles, some of bright colours, the commonest plains species of a dull black colour; two are abundant, the spotted *Chrysomela*, *C. guttata*, Geb., and the unspotted species *C. Pasceri*, Jac. *Paropsides hieroglyphicus*, Gebl., breeds freely on pear trees in the hills and is a pest in Shillong.

Galerucinæ Halticini.—A large group with over 150 described Indian species and many more to be recorded. *Podontia* is common in the hills and moister plain areas. *P. affinis*, Grond., and *P. 14-punctata*, Linn., being the familiar species. The latter is recorded as breeding in Calcutta on *Spondias mangifera*; the larva is covered in excrement and pupates in a rough cell of earth in the soil, the imago appearing yearly in August (Indian Mus. Notes, Vol. IV, p. 68). *Clitea picta*, Baly., is a small oval brown and black species found feeding, as an imago, on the leaves of Bael (*Aegle marmelos*). The beetles jump freely as do most of this group. The larva is found boring in the shoots of this plant, the slender twigs being tunnelled down the centre but little harm being done. The

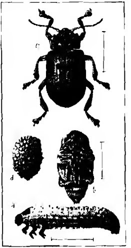
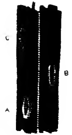


Fig. 241.—PODONTIA 14 PUNCTATA. (I. M. N.)

PLATE XXIII.—PHIDODONTA MODESTA.

SUGAR-CANE HISPA.

- Fig. 1. Eggs ...
  - A. B. A day after laying.
  - C. Before hatching.
- „ 2. Newly hatched larva. x 3.
- „ 3. Larva in mine in cane leaf.
- „ 4. Full-grown larva. x 3.
- „ 5. Pupa ...
  - A. Ventral aspect. x 3.
  - B. Dorsal aspect. x 3.
  - C. Just before emergence. x 3.
- „ 6. Imago ...
  - A. Just after emergence. x 3.
  - B. 15 minutes after emergence. x 3.
  - C. 30 „ „ „ x 3.
  - D. 60 „ „ „ x 3.
- „ 7. Imago, to show disposition of spines.



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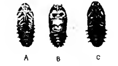

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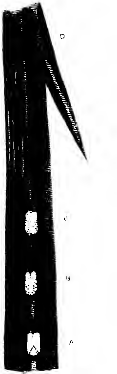

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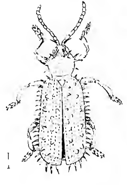

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larva is soft, whitish with few very short hairs, the head brown, the tiny round spiracles on the dorso-lateral line. Behind the head is a distinct prothoracic shield, and over the anus is a flat black plate with short hairs round; this plate is at an angle to the long axis of the body, facing dorsally and posteriorly and may be for the purpose of enabling the larva to exert pressure by placing this against the wall of the tunnel. *Chætocnema basalis*, Baly., is the flea beetle of rice, a small active beetle that leaps readily. This and other genera include the common flea beetles known as destructive to crops in all countries. Several species are found in Indian crops attacking wheat, sann hemp, mustard and brinjal. The larvæ of these small beetles are miners in the tissues of the plant. *Luperomorpha weisi* is recorded as attacking mango trees in Purulia (Indian Mus. Notes, Vol. V, p. 125). *Haltica cyanea*, Web., is a common steel-blue beetle of moderate size. It breeds freely in the rains and until December, the black larvæ feeding on a very common weed, *Ammannia rotundifolia* (*Lythraceæ*) which comes up abundantly after the rains. This species is curiously plentiful in some years, but is very localised and swarms have been observed clustered in a patch in a single field; they are gregarious when abundant, a patch of ground sometimes black with them. The winter is spent normally in pupation in the soil, the beetles emerging in March and waiting till food can be obtained. This is one of the perfectly harmless insects so often reported as injurious, owing to its presence in large numbers in crops. Its ally, *H. cærulea*, is the prey of the bug *Zicrona cærulea* as is probably also this species (see Pentatomidæ below).

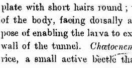
Fig. 235.—HALTICA CYANEA LARVA, × 4.

Galerucini.—Over 250 species are recorded and this number will probably be doubled when the Fauna volume comes to be prepared.

Oides occurs plentifully in forest localities and occasionally in the plains in the form of *O. bipunctata*, F., an oval orange beetle with a black blotch of varied size on each elytron. The larva is yellow and feeds on the leaves of the common wild creeper *Vitis trifolia*: when full-grown it pupates on the leaf under a few coarse threads.

Aulacophora is the commonest beetle genus in the plains with three common species. *A. foveicollis*, Kust. (= *abdominalis*, G. et H.), is

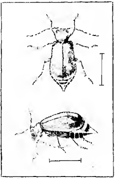

Fig. 236.—AULACOPHORA FOVEICOLLIS. [I. M. N.]

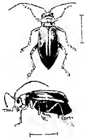

Fig. 237.—MIMASTRA CYANEA.

deep orange above, while *A. excavata*, Baly., has the elytra deep blue, *A. atripennis*, Fabr., the elytra black, and *A. downesi*, By., the elytra black with a yellow basal patch. The last is rarer than the first three. There are a number of species of this genus and the whole classification of these beetles is in confusion. Though *A. foveicollis*, Kust., is extremely common, nothing is known of its life-history and all attempts to solve the problem hitherto have failed. It is a destructive insect to young cucurbitaceous plants, eating the leaves. (The larva of its ally *Diabrotica* in America, mines in the stem a little below ground, while the beetle behaves as our species does.) *Hoplasoma* also includes several common species whose life-histories appear to be unknown. *Mimastra cyanea*, Ho., is principally a defoliator of forest trees and occasionally occurs in numbers. The beetle emits an acrid yellow fluid from the head. Several other species are common in jungle but not in cultivated areas. We figure all stages of *Galerucella rugosa*, Jac. (Plate XXII), whose larva feeds on *Polygonum*; this genus and *Haplosonyx* are abundantly represented even in the plains. Another *Galerucella* is destructive (in its larval and imaginal stages) to the Waternut or Singhara crop (*Trapa bispinosa*), destroying the leaves of this valuable plant.

Hispinæ.—Cryptostome beetles, in which the antennæ are set closely together on the front of the head, but without the produced prothorax covering the head, which characterises the next sub-family.

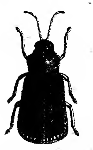

Fig. 238.—Gonophora bengalensis.

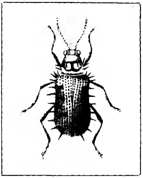

Fig. 239.—Hispa ænescens, × 7.

These beetles have a characteristic facies of their own, being usually flattened, the sides of the elytra parallel, the prothorax narrow, the integument either much pitted in lines or with regularly arranged spines. The antennæ project in front of the small head; the legs are short, the elytra often have truncate ends. The colouring is varied, browns, metallic blacks and occasionally brighter metallic tints predominating. Some species are evidently cryptically formed and coloured, escaping notice when resting motionless on a young leaf tightly pressed to the surface.

The life-history of several species in India has been worked out (Plate XXIII). The essential features are that the egg is laid in the tissues of a leaf or plant, the resulting grub mining in the tissues, and producing a "blotch" mine. Moults take place inside the mine and the larva is much flattened, though in some cases provided with legs. Pupation takes place in the leaf. The beetles are similar in appearance in both sexes. So far as known, all *Hispinæ* have such a life-history and the larva lives concealed in the tissues of plants. Hibernation and other periods of rest take place in the imago state.

One species, *Hispa ænescens*, By., is a serious major pest, and another *Leptispa pygmæa*, By., occasionally rivals it. Others are minor pests or live in uncultivated plants. Hymenopterous parasites are the only known check on the increase of these insects. H. Donckier de Donceel's Catalogue (Ann. Soc. Ent. France, 1889, LXVIII, p. 540), enumerates 111 Indian species, chiefly of the following genera :—*Callispa* 14, *Anisodera* 12, *Gonophora* 9, *Downesia* 10, *Platypria* 7, *Hispa* 42. A few, including plains species, have been described since. Gestro's papers (Ann. Mus. Civ. Genova), Baly's catalogue of *Hispidæ*, and Weise's recent papers (Deutsche Entomologische Zeitschrift) describe the majority of our species.

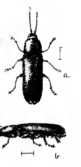

Fig. 240.—LEPTISPA PYGMÆA. (I. M. N.)

Leptispa pygmæa, Baly., is a narrow steel-blue species destructive to rice in Malabar and occasionally found elsewhere in the plains. Its life-history is unknown. *Amblispa lævigata*, Guer., is a spineless black insect found on the leaves of the high grass in Canara and the Himalayas. *Gonophora bengalensis*, We., is a pretty yellow-brown species with black spots found abundantly during the rains in submontane localities.

Platypria includes *P. Andrewesi*, We., described from specimens reared from ber (*Zizyphus jujuba*) and common in widely spread localities in the plains. The larva does not remain in one mine but moves about, eating into the leaf, eating out a kind of pocket and then emerging to commence a fresh pocket. The larva (fig. 241) is flat, the head large and hard, with short antennæ and a lateral cluster of ocelli; the prothorax bears a dorsal and a ventral shield ; the segments are produced laterally and bear a terminal backwardly-curved process ; the spiracles are on the dorsum ; the legs are well developed and the larva runs actively; the abdomen terminates in a flat chitinous plate with a lateral process, the anus being ventral. It pupates in a special pocket in the leaf. The pupa is similar, but the fourth abdominal segment is drawn out laterally into a strong backwardly-directed process on the dorsum.

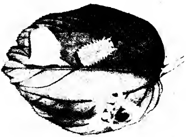

Fig. 241.—PLATYPRIA ANDREWESI. LARVA ON BER LEAF; OLD AND PUPAL MINES, × 3.

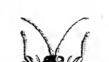

Fig. 242.—PLATYPRIA ANDREWESI.

P. echidna, Guer., is a common form in the Western Ghauts and Nilgiris. *Hispa* (*Phidodonta*) *modesta*, We., has been bred in sugarcane; its life has been fully described (Mem. Agri. Dept. Ent.), as has also that of *Hispa ænescens*, By. This last is a very important pest in rice-growing tracts and may be distinguished by the form and position of the prothoracic spines, the small tooth at the lower edge of the basal antennal joints, the absence of spines on the antennæ above and the metallic black-green colour. The discrimination of Hispids is not difficult if attention be paid to such points, but the student may be cautioned against hasty identification without very careful examination.

Cassidinæ.—Tortoise Beetles. The characteristic of these beetles is the flattening of the body and the extension of the pronotum over the head. The form is oval or rounded, the outline of the extended prothorax continuous with that of the elytra and giving the insect the appearance of a tortoise. The colouring is either dull green or dry grass colour, or is peculiarly brilliant, the living insect having a glittering golden hue with a ground tint of red, pink or green. In appearance these are perhaps the most striking of all insects, living jewels of the most delicate beauty. The object of this colouring is not clear, though the dull green ones are evidently cryptic, in conjunction with their form and immobile attitude on the plant.

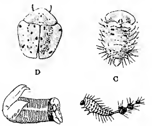

Fig. 243.—Aspidomorpha miliaris. A. Egg mass, B. Larva, C. Pupa, D. Imago.

Few details are available as to the life-history. Eggs are of two types, single eggs laid on the leaf (*Coptocycla*), egg masses containing many eggs (*Aspidomorpha*); larvæ are flattened, with processes bearing spines, with three pairs of legs and having an anal process which can be turned over the dorsum and bears the dried excreta. We figure such a larva (Plate XXIV). These larvæ are found on the leaves of their foodplants and, in the moist tropical zones where they are of large size, they are extremely striking. Their food is the epidermis or tissues of the leaf and they are nocturnal in habit as a rule. Pupation takes place on the leaf and the processes on the body are a marked feature of these

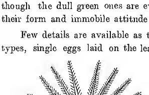

Fig. 244.—Larva of Metriona circumdata.

PLATE XXIV.—CASSIDINÆ.

Fig. 1. *Calopepla hexagona*, larva from above, with its attached moult.
,, 2. Anal segment with the moult removed.
,, 3. Pupa, from above.
,, 4. Beetle.
,, 5. *Coptocycla sexpunctata*.
,, 6. *Prioptera 10 maculata*.

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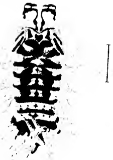

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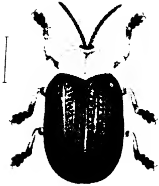

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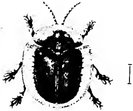

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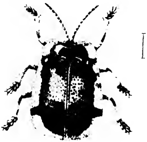

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insects. None can be reckoned as pests since none occur abundantly; *Convolvulaceæ* are their food especially, several feeding on sweet potato (*Ipomœa batatas*) and on garden creepers. The majority breed only in the rains since there is then only a sufficiency of food. Apparently the imago goes into hiding for the intervening seasons, but accurate data on this and other points in the life history are not available.

The species are described by Bohemann in his Monograph, dated 1850-1862, and a number of species have been described since. *Hoplionota* (6), *Prioptera* (8), *Calopepla* (4), *Epistictia* (3), *Chirida* (4). *Aspidomorpha* (14), *Cassida* (26), *Laccoptera* (4), *Coptocycla* (13). are the genera. The larger and more brilliant species of *Calopepla*. *Aspidomorpha*, etc., are wholly hill or forest forms, and only the duller green *Metriona* and *Coptocycla* and the smaller *Aspidomorpha* occur in the plains. *Aspidomorpha miliaris*, Fabr., was reared in Calcutta on Convolvulus; it commonly attacks sweet potato also. The life-history has been worked out in the Philippines by W. Schultze, who figures all stages. (Philippine Journal of Science, III. p. 261.) The duration from the egg to the emergence of the adult was 38 days, there being four larval moults before the pupal moult. He remarks that the larvæ feed and pupate in groups. The student should consult this paper, as also Muir and Sharp's (Trans. Ent. Soc., London, 1904, p. 1), and Muir and Kershaw's (Loc. Cit., 1907, p. 249), for interesting notes on the eggs and transformations of this group.

Metriona circumdata, Hbst., is the commoner green form breeding on the same plant, as also does the common six-spotted *Chirida sexnotata*, F., both of these laying eggs singly on the leaf. *Cassida dorsonotata*, Boh., is common in the moister areas, while *Coptocycla varians*, Hbst., is found in abundance breeding on the wild Ipomœa on sand dunes (*Ipomœa pes-capræ*); the single oval egg is laid on the leaf and is fastened with short brown filaments from the side of the egg on to the leaf: the green larva is flattened and very difficult to see resting by day motionless on the plant.

Collecting.—The beetles are easily collected and preserved; their food-plants should in all cases be noted. Whenever possible they should be kept alive with food till eggs are obtained and the larvæ studied. This is not always possible and the life-histories of some of our commonest species still remain unknown. For this reason every larva found deserves careful rearing; larvæ are preserved in formalin. The student may be cautioned against hasty identification of specimens that look extremely alike, more especially in the *Hispides*. There is no group that requires more careful scrutiny before pronouncing two specimens to belong to the same species, and this is of great importance in the economic species. There is also no group that offers such scope to the inquirer, especially in the bionomic aspect. To the naturalist living in a forest or hill district there is immense scope and the fauna of any one place will take years to procure and work out properly.

CERAMBYCIDÆ.—(*Longicornia*).

Antennæ long, their bases partly encircled by the eyes. Upper surface pubescent.

This large family of large insects is readily recognisable from their general form and their long antennæ. They range from under half an

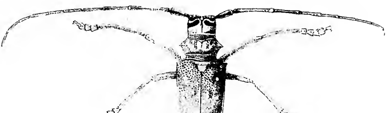


Fig. 215.—BATOCERA RUBRA.

inch to over one inch in length, the body robustly built and the integument hard. The colours are sombre or bright, many being cryptically coloured, others exhibiting Mullerian mimicry, imitating the colouring of warningly coloured insects.

The head is distinct and well developed, with large eyes and powerful trophi, the heavy biting mandibles being prominent. Antennæ are long, dentate in some forms, in others with tufts of hair. The prothorax is powerful, accurately adapted to the body. The elytra cover a pair of ample wings and are closely applied to the abdomen. In some cases they are abbreviated or narrowed and do not wholly cover the abdomen. The legs are long, the tarsi pubescent. Males are similar to the females, the former having larger mandibles and distinctions in the antennæ and forelegs and, as a rule, the antennæ are longer. They stridulate by moving the prothorax against the body, the posterior edge of the prothorax rubbing on a corrugated surface on the mesothorax and so producing an audible squeak.

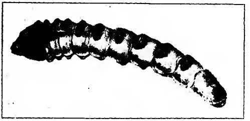


Fig. 246.—Cœlosterna scabrata larva.

The life-history, so far as known, is uniform throughout the group. The females lay large eggs singly in cracks of the bark of trees or on bamboos. These eggs hatch to legless larvæ which tunnel in the hard woody tissues, eating out large galleries in which they live. The larva is characteristic in form, generally similar to that of Buprestidæ but with the abdomen more developed and the swollen prothorax less marked. The head is small, with powerful biting mandibles. The thorax is slightly swollen, with a broad dorsal plate, without legs, the abdomen often has dorsal plates on each segment. The pupa is found in the tunnel, in a chamber formed by closing up the tunnel at its head and tail, or in a cocoon of white hard material derived from the excrement. The length of the life-history is known in few cases but in species investigated elsewhere, has been found to be very long, as much as three years being spent in the larval stage. This is due possibly to the lack of nutrition in the food of the larva, the dry woody material not containing much nutriment; a great amount of it must pass through the alimentary canal in order to supply the necessary food and a long period is apparently consumed in obtaining this. The larval galleries are often very large and extend to a great length through the trunks of trees.

The family is a very large one, principally confined to forest areas and of no importance in Agriculture except in special cases. Few are found in the cultivated plains and the bulk of the species are purely forest haunting insects. The Indian species are being described by Gahan in the Fauna of India.

The family is divided into two sub-families :—

Cerambycinæ.—Head in front oblique or sub-vertical, last joint of palpi not pointed in tront. Fore tibiæ not grooved beneath.

Laminæ.—Head in front vertical or bent inwards well below the thorax. Last joint of the palpi pointed at the end. Fore tibiæ generally with a groove beneath. (Gahan).

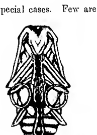


Fig. 247.—BATOCERA RUBRA PUPA.

Cerambycinæ.—Gahan makes four sub-families :—

Prionini.—Distinguishable as a rule by the sharp lateral margins of the prothorax. *Distenini*. Ten hill forms. *Lepturini*. Twenty-three hill forms. *Cerambycini*. Embraces most of our forms but is not readily distinguishable in the case of hill forms, except from *Prionini*.

Prionini.—An assemblage of 53 Indian species, of which two only are common in the plains. They are large dark brown insects, the antennæ long, the prothorax usually spined, the mandibles often very long, curved and powerful. *Dorysthenes montanus*, Guer., is stated to come out of the soil in the Nilgiris in such numbers as to cover the soil; this occurs in April, May and June, the observer (Mr. Perrotet) further remarking that the bears eat these beetles. (?) (Guer. Men., Rev. Zool., 1840, p. 40.) The large brown beetle that flies into lights in Southern India and bites so freely is *Priotyrannus mordax*, Wh. The less formidable *Paraphrus granulosus* Thoms. comes into houses at night in Behar. *Macrotoma crenata*, Fabr., is a common plains species, widespread over India, found under fallen leaves and at light. *Aegosoma costipenne*, Wh., is recorded as boring into teak trees in Assam. (I. M. N. II, p. 12.) *Acanthophorus*

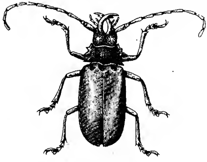


Fig. 248.—PRIOTYRANNUS MORDAX.

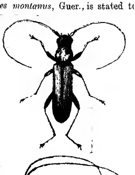


Fig. 249.—HYPOESCHRUS INDICUS.

serraticornis, Oliv., occurs in South India where it bores in mango and has been found as far North as Amballa, and *A. modicus*, Gah., is known only from Lahore.

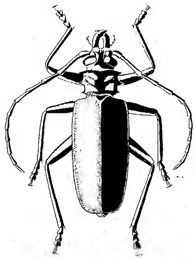


Fig. 250.—ACANTHOPHORUS SERRATICORNIS.

Cerambycini.—Gahan lists 309 species from the Indian region, divided into 20 groups. It is impossible to discuss so large a number of forms here; about 12 may be considered as common in the plains. We figure *Hypoeschrus indicus*, Gah., which bores in the Sal tree.

Xystrocera globosa is a reddish brown beetle, of about one inch length, with a conspicuous longitudinal band of metallic green along the elytra, found very widely. It represents the third group *Œmini.* Mr. Willcocks states that it is, in Egypt, a serious enemy of the Siris tree (*Albizzia lebek*).

Stromatium barbatum, Fabr. (*Hesperophani*), is perhaps the most abundant Cerambycid beetle in the plains, and is known to breed in Khair (*Acacia catechu*). teak, sissu and other dry timber; it is a dull brown insect, whose most interesting feature is the patches of silky hair on each side of the prothorax of the males; these are so placed and set that they catch the light in a very marked way, reflecting it towards the front, so that looked at from in front the insect appears to have two large shining eyes: this may be mere fancy or may serve a useful purpose in courtship or defence. This beetle is known to emerge yearly in early June.

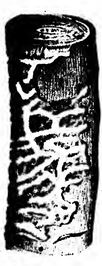


Fig. 251.—SAL WOOD ATTACKED BY HYPOESCHRUS INDICUS.

The Cerambycines contain a large number of forms common or injurious. *Plocederus obesus*, Gah., is the insect recorded as destroying sal (I. M. N. I, p. 91); its cocoons, which are large, hard and formed apparently wholly of calcium carbonate, are striking objects. *Æolesthes holosericea*, Fabr., is recorded (I. M. N. I, p. 89) as breeding in sal wood (*Shorea robusta*). It is an extremely handsome beetle of rather over an inch length, covered with fine pubescence that gives beautiful silky reflections. It is one of the common plains species. *Diorthus simplex*, Wh., is another common and widespread species, of a dull brown colour, resembling the preceding generally but with a distinct scar at the apex of the basal antennal joint bounded by a little ridge. *Derolus demissus*, Pasc., is a smaller brown species without the antennal scar and with a fine ridge along the ventral face of each femur.

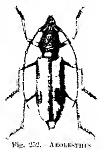


Fig. 252.—AEOLESTHES HOLOSERICEA.

With the *Callichromini*, we leave the dull brown species and come to metallic blue and green species of larger size and more slender build. *Chloridolum alcmene*, Thoms., is the species found boring in the trunks of orange trees in Coorg (see Agri. Journ., India, Vol. 1, p. 129). It is a deep blue insect, the legs dark coloured; it is recorded also from Assam, Andaman Isles, and Burmah, while Mr. Andrewes found it in the Nilgiris. No other species is notable and none occur in the cultivated plains: some are known to emit an odour which is pleasant and possibly connected with sex.

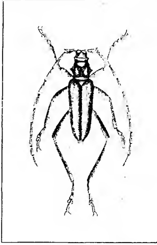


Fig. 253.—CHLORIDOLUM ALCMENE.

The *Clytini* include a large number of hill forms, chiefly slender insects with a cylindrical or globose prothorax and marked in bright colours. *Xylotrechus* has the antennæ wide apart and the front with ridges; it includes the White Borer of Coffee. *X. quadripes*, Chevr., whose larva lives in the stems of the coffee plants. Much has been written about this pest which occurs in the coffee districts of South India and is most destructive to coffee grown under too dense shade. It is found also in Assam, Sylhet and Burmah and is an example of an ordinary indigenous insect which finds abundance of a cultivated plant in which it can breed and thus becomes

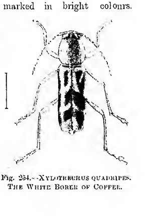


Fig. 254.—XYLOTRECHUS QUADRIPES. THE WHITE BORER OF COFFEE.

a pest. The reader should consult the account of Dunning (Tr. Ent. Soc., London, 1868, p. 105), of Bidie (Report on the Ravages of the Borer, 1869, Madras), and that of Taylor (The White Borer, 1868, Madras).

Caloclytus is a large genus of yellow banded beetles, one of which is occasionally extremely abundant in the plains. This is *C. annularis*, Fab., a slender beetle clothed in yellow pubescence, with dark bands on the thorax and elytra; it lays its eggs on bamboos, the larva living in the bamboo and gradually destroying it; the life-history occupies one year, the beetle being easily reared in captivity; large numbers have been found to emerge from a thatched roof in which new bamboos were used, their emergence taking place in May. Other species are extremely common in the hills, as are also some species of *Clytus* and *Demonax*.

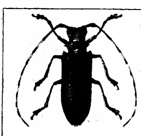


Fig. 255.—Cœlosterna scabrata.

Lamiinæ.—The revision of this sub-family is not yet complete and we can only mention the common species of the plains, with the caution that the publication of the revision in the Fauna Volume will inevitably alter the nomenclature of the species named. *Batocera rubra*, Linn. (figs. 245 and 247), is the large beetle found throughout the plains, whose larva is common under the bark of trees; it appears to occur chiefly in decaying bark and the trees felled in Pusa contained abundance of the large larvæ and pupæ. It is an extremely handsome insect, the largest of the common plains species. It is common also in mango, and E. P. Stebbing has described its occurrence in the Duki fig (Ind. For. Bull. 10). *Cœlosterna spinator*, F., is a common beetle, breeding in babul (*Acacia arabica*); the beetle has been found to eat the bark of cotton plants and, when abundant, as it occasionally is, to do harm in this way. *C. scabrata*, F. (figs. 246 and 255) has been reared from *Casuarina equisetifolia* in South India, where it is very destructive to young trees, and also from mulberry. *Sthenias grisator*, F., is a smaller beetle reported to girdle *Tabernæmontana alba* branches in South India, as well as to cut down rose bushes (Ind. Mus. Notes III, p. 40). *Olenecamptus bilobus*, F., is common in the plains on pakur, gular and other fig trees; it is conspicuous by the round white spots on the smooth brown elytra and is likely to be found everywhere in the plains. *Apomecyna histrio*, F., and *A. pertigera*, Thoms., are common among cultivated crops: both are of small size, dull brown in colour, with many small white spots disposed over the elytra. The latter have been reared from the stems of the common pumpkin (*Cucurbita pepo*) in which it occurs abundantly (Plate XXV).

Amongst the many species of *Glenea*, *G. spilota*, Thoms., is known to breed in the trunk of the silk cotton tree (*Bombax malabaricum*), the larva being found abundantly in the decaying trunk after the plant has dried, in common with a host of other insects. *Monohammus nivosus*, Wh., is the commonest representative of this immense genus, an insect found on the Ak plant (*Calotropis* spp.) in the plains. Its larva is found in the stem of the plant, tunnelling up the centre and the beetle is to be found practically wherever this plant grows.

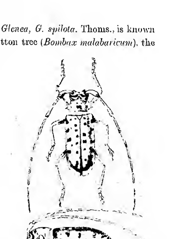


Fig. 256.—MONOHAMMUS VERSTEEGI.

The following list of plants bored by Cerambycidæ is compiled from Indian Museum Notes (I.M.N.), the reports of the Forest Zoologist (E.P.S.), of the Entomologist, Indian Tea Association (C.B.A.), and our own records. We have included borers of other groups such as the Arbelidæ, Cossidæ, Buprestidæ, etc., but the records are extremely meagre and show how little this subject has been investigated. The borers in dry wood, etc., of the Bostrichidæ, etc., and the larvæ living in the branches, etc. (as the Curculionidæ), are omitted.

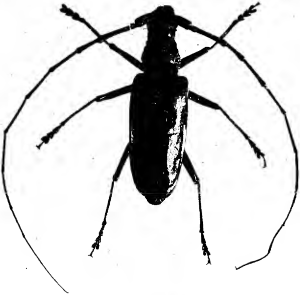


Fig. 257.—NEOCERAMBYX PARIS.

	Plant.	Bored by.
Akh.	*Calotropis gigantea.*	*Monohammus nivosus.*
Asan.	*Terminalia tomentosa.*	*Æolesthes holosericea* (I. M. N.).
Babul.	*Acacia arabica.*	*Æolesthes holosericea* (I. M. N.).
,,	,, ,,	*Cœlosterna spinator* (I. M. N.).
Ber.	*Zizyphus jujuba.*	(*Arbela tetraonis.*)
Bamboo.	*Dendrocalamus strictus.*	*Stromatium barbatum* (E. P. S.).
,,	*Bambusa* sp. (dry).	*Caloclytus annularis.*

Casuarina.	*Casuarina equisetifolia.*	(*Arbela tetraonis*).
,,	,, ,,	*Cœlosterna scabrata.*
Coffee.	*Coffea arabica.*	*Xylotrechus quadripes* (I. M. N.)
,,	,, ,,	(*Zeuzera coffeæ*) (I. M. N.).
Gular.	*Ficus glomeratus.*	*Batocera rubra.*
Guava.	*Psidium guava.*	(*Arbela tetraonis*).
,,	,, ,,	*Æolesthes holosericea.*
,,	,, ,,	(*Belionota prasina*).
Khair.	*Acacia catechu.*	*Stromatium barbatum* (I. M. N.)
Lime.	*Citrus medica.*	*Chloridolum alcmene.*
Orange.	,, *aurantium.*	(*Agrilus grisator*).
Litchi.	*Nephelium litchi.*	(*Arbela tetraonis*).
Mango.	*Mangifera indica.*	*Acanthophorus serraticornis.*
,,	,, ,,	*Stromatium barbatum.*
,,	,, ,,	*Batocera rubra.*
,,	,, ,,	(*Arbela tetraonis*).
Pumpkin.	*Cucumis melo.*	*Apomecyna pertigera.*
Sal.	*Shorea rabusta.*	*Plocederus obesus* (I. M. N.).
,,	,, ,,	*Hoplocerambyx spinicornis* (I. M. N.).
,,	,, ,,	*Cœlosterna scabrata* (I. M. N.).
,,	,, ,,	(*Chrysobothrys sexnotata*) (I. M. N.).
,,	,, ,,	*Æolesthes holosericea* (E. P. S.).
,,	,, ,,	*Acanthophorus serraticornis* (E. P. S.).
,,	,, ,,	*Dialages pauper* (E. P. S.)
,,	,, ,,	*Hypæschrus indicus* (I. M. N.).
Sandal.	*Santalum album.*	(*Zeuzera coffeæ*).
Simul.	*Bombax malabaricum.*	*Plocederus obesus* (I. M. N.).
,,	,, ,,	*Glenea spilota.*
Sissu.	*Dalbergia sissu.*	*Stromatium barbatum.*
Tea.	*Camellia theifera.*	(*Arbela dea*). (C. B. A.).
,,	,, ,,	(,, *quadrinotata*). (C. B. A.).
,,	,, ,,	(*Phassus malabaricus*).

Teak.	*Tectona grandis.*	*Batocera rubra* (I. M. N.).
,,	,, ,,	*Stromatium barbatum* (I. M. N.).
,,	,, ,,	*Stromatium longicorne* (I. M. N.).
,,	,, ,,	*Aegosoma costipenne* (I. M. N.).
,,	,, ,,	*Æolesthes holosericea* (I. M. N.).
,,	,, ,,	(*Psiloptera fastuosa*) (I. M. N.)
,,	,, ,,	(*Cossus cadambæ*) (I. M. N.)

RHYNCHOPHORA.

A series of beetles recognised by the tarsi, which are similar to those of the Phytophaga (fig. 183), by the antennæ, usually clubbed and often elbowed, and by the rostrum, the head being drawn out more or less distinctly, so that the mouth, instead of being ventral, is anterior to the eyes, and often at the apex of a distinct beak-like prolongation of the head. It is difficult to place a few forms and to distinguish exactly between this series and some of the Phytophaga, but such cases occur very rarely. The Rhynchophora are on the whole a distinct series, all phytophagous, with leg-less larvæ usually living concealed (pace *Cionus*) and including a large number of boring insects found as larvæ in plants.

ANTHRIBIDÆ.

Rostrum short and blunt. Antennæ straight, usually clubbed, eleven joints. Tarsi of four joints, third small and hidden.

Dull coloured beetles of small size and not often found, the body clothed in pubescence. These beetles are found on tree trunks, on mushrooms, on dead wood; few are very active, though a few can leap (*Aræcerus*). The larvæ are white grubs similar to those of *Curculionidæ* but sometimes with legs. They are found in seeds and in wood. Though few Indian species are known, many probably occur and their identification is not easy. Malaya is the head-quarters of the family. The student who specialises in this family will find a list of the known species with bibliographical references in Ann. Soc. Ent. Belge. XLIX, p. 218 (1905). Bovie here lists 91 species as occurring in India, Burma and Ceylon. Jordan has described the majority of the forms from our limits.

Eucorynus crassicornis, Fabr., is a dark coloured insect found not uncommonly in tree bark in the plains, while *Phlœobius alternans*, Wied., has been found on plants. *Aræcerus fasciculatus*, de G., is cosmopolitan and has been recorded as breeding in Areca nut in India. It is stated to have been distributed in coffee beans in which it breeds freely. This, or a very closely allied species, breeds freely in old dried cotton seeds (Plate XXVII) that remain on the plant after picking, and we have reared very large numbers from such seeds. Another has been reared in dry chilli pods and a third from the stem of parwar (*Trichosanthes anguina*). The cosmopolitan species feeds on a great variety of substances and is variable in appearance; the discrimination of species is not easy in this genus.

CURCULIONIDÆ.—*Weevils.*

Labium absent. Antennæ clubbed and elbowed. Head produced into a rostrum. Fourth tarsal joint reduced.

Weevils are recognisable by the rostrum and elbowed antennæ in almost all cases. They vary in size from one-eighth of an inch in length to nearly two inches, and include a large number of forms a little more than a quarter of an inch long. The colours are commonly dull, browns and greys predominating, many black, a few a rich red brown and some green. In many species the body is clothed in scales, the actual integument being dark coloured, the delicate scales grey, buff,

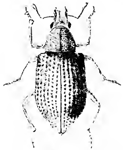


Fig. 258.—BRACHYASPISTES TIBIALIS. × 5. [I. M. N.]

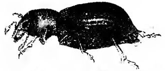


Fig. 259.—BRACHYASPISTES TIBIALIS. × 5. [I. M. N.]

green or other light tints. When magnified these scales give the insects a very beautiful appearance, one that cannot be appreciated by the naked eye. In some species the body is not clothed with scales but with an "efflorescence," a delicate mealy covering produced by the insect itself, and suggesting that a strong alkaline solution has been excreted and evaporated, leaving a white floury coating. The body is often short and thickset, the head drawn out into a beak of very varied form. Small compound eyes are placed at the base, the antennæ projecting from the side of the rostrum. The antenna consists of a slender elongate basal segment, the scape, seven or six short slender segments forming the funicle and a club composed of three or four expanded segments (Fig. 137). The minute biting mouth-parts are situated at the apex of the rostrum; the latter may be short and thickset or long, slender and either curved or nearly straight. In a majority, there are the scars of the bases of temporary mandibles found in the newly hatched weevil, on the mandibles; these were used in emergence from the cocoon or ground and shed. The prothorax is well developed, the abdomen large and completely covered by the elytra which fit closely to the body and cover the folded wings. The legs are moderately long, the femur often swollen at the apex, the tarsi of four apparent joints, of which the basal three are usually flattened and densely pilose. Males and females are similar in appearance, the former often smaller and in some species readily distinguished by the form of the rostrum, fore-legs or antennæ.

Though the family is a very large one, the life-histories of only a very few are known. So far as known, the eggs are of two types: eggs laid in exposed positions on the outside of a plant are small oval objects, smooth, with a hard shell; those which are deposited in the tissues are soft, elongate and white. They are laid singly, and usually in considerable number spread over a number of plants. Larvæ are, as a rule, internal feeders and are white soft legless grubs (Plates XXVI, XXVIII), with a distinct brown head and a much wrinkled body, which is fleshy and slightly curved. The majority of the known larvæ are found in the tissues of plants, in roots, stems, fruits, twigs and other parts; None are known to be other than herbivorous. Pupation occurs in the plant, and there is great variety in this respect. A few make cocoons of fibres; many pupate in the tunnel without covering, though in a distinct closed chamber. The larvæ which live exposed make a case of excrement or of gummy material derived from the anus.

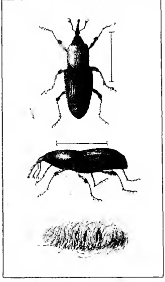


Fig. 260.—Odoiporus longicollis, imago and cocoon.

The weevils which emerge are active insects, diurnal or nocturnal, feeding on leaves and other parts of plants or on plant sap. None are known to be predaceous, though at least one is probably so. The duration of each stage varies with the species. Some are one-brooded, hibernating as the imago and passing long periods in the imago form, until they are able to lay eggs in the tissues in which the larvæ can live. Others are many-brooded, and one brood succeeds another so long as food is available. In these cases hibernation appears to be passed in the larval or pupal form.

Weevils have the habit of "shamming dead:" when approached the legs and antennæ are folded close to the body and the insect drops to the ground. This is a valuable defence, especially in thick vegetation, the insect falling to the soil and being extremely hard to find. Since all are herbivorous and some abundant, the family includes many destructive species, whose ravages, especially in the larval stage, are of importance in Agriculture. Our knowledge of these insects is slowly growing and many yet remain to be worked out. Owing to their concealed lives and to the often nocturnal habits of the imago, they are difficult to check, no stage being exposed to any particular measures that can be adopted. A few are destructive, not in the larval but in the imaginal stage, the weevil living for long periods and destroying leaves. The mango weevil, the melon weevil and apple weevil attack fruits, the sweet potato weevil, tubers, the cane weevil the roots, the cotton stem weevil, palm weevil and jute weevil the stems, while the white and green weevil eat the leaves, and the rice and wheat weevils stored grains. The enemies and checks of these insects are little known: parasitic insects check the larvæ and the weevils are probably destroyed by birds and by predaceous insects.

The family is one of the largest, and though many species are known, no thorough account of the group is in existence. They occur

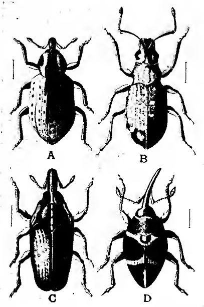


Fig. 261.—A. HYPERA VARIABILIS, B. MYLLOCERUS DISCOLOR, C. ALCIDES LEOPARDUS, D. BALANINUS C. ALBUM.

in all parts of the tropical and temperate regions. In India, the plains fauna is rich in species, though more are to be found in the submontane forest and jungle areas. The family as it occurs in India is being described in the Fauna of India by G. A. K. Marshall.

The classification of the *Curculionidæ* is too vast to be entered into here. One has but to glance at the vast array of groups, divisions, legions, cohorts, tribes. etc., into which the family has been divided to realise its complexity. A complete revision of the family in the light of new knowledge will have to be done when the monographs on the regional faunæ are more complete. As in other complex groups of Coleoptera, there seems to be no immediate prospect of any thorough revision owing to the complexity of the family and its vast number of species. About 1,500 Indian species are probably already described or recorded, but an equal number at least will probably be added now and new forms are found constantly.

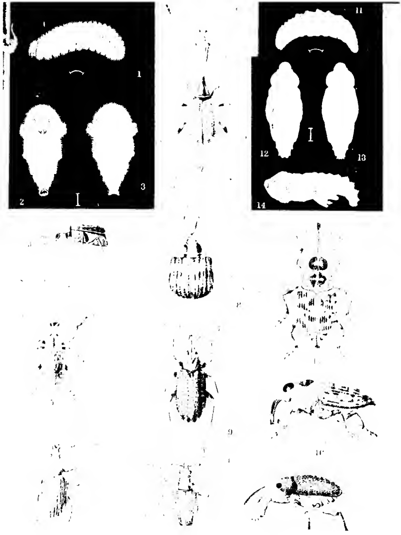
Brachyderinæ.—*Blosyrus asellus*, Oliv., is a grey weevil, with thickset abdomen and elytra, found commonly feeding on leaves from August to December. *Astycus lateralis*, F., is the common green weevil of the plains of India, found feeding in abundance upon cultivated plants. *A. chrysochloris*, Wied., is the larger metallic green species common in Assam. *Tanymecus indicus*, Fst., is one of the many weevils which are so abundant on soil and eat young plants. It is extremely common in the Gangetic plain and appears regularly twice in the year at the commencement of the kharif and rabi seasons. *Tanymecus circumdatus*, Wied., is common on plants, a delicate green form with longitudinal stripes, and *T. chloroleucus*, Wied., is also abundant, uniformly clothed in almost white scales. The genus is a very large one with many species in the plains. Their larvæ will probably be found in the roots or underground stems of plants. *Atmetonychus peregrinus*, Oliv., is also found, a grey much roughened weevil found on young plants (Plate XXVII, fig. 10).

Otiorhynchinæ.—*Episomus lacerta*, F., is a comparatively large grey weevil that has been found in numbers on cotton plants, feeding on the bark (Plate XXVII, fig. 6).

PLATE XXVII.—CURCULIONIDÆ.

WEEVILS.

Fig	1	Larva of Aræcerus sp (Cotton seed weevil)	
,,	2	Pupa ,, ,,	
,,	3		
,,	4	Imago ,, ,,	x 6
,,	5	Phytoscaphus triangularis	x 3.
,,	6	Episomus lacerta	x 2
,,	7	Apoderus scutellaris	x 4
,,	8	,, tranquebaricus.	x 4
,,	9	Xanthochelus superciliosus	x 2.
,,	10	Atmetonychus peregrinus	x 2
,,	11	Phylaitis sp (Cotton stem weevil), larva, pupa, imago	
,,	12		
,,	13		
,,	14		
,,	15		
,,	16		
,,	17	Balaninus Bomfordi	x 6.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Myllocerus is an important genus of weevils in India with several common species. The commonest is the "White weevil," *M. maculosus*, Desb., described from Cawnpore specimens (Ind. Mus. Notes, Vol. IV, p. 111). This is abundannt everywhere in the plains but its life-history is still unknown *M. setulifer*, Desb. (Fig. 262), described in the same publication, is found attacking flowers and is not strictly a plains species. *M. discolor*, Boh. (Fig. 261), has been reared from grubs found at the roots of cane plants, the grub and pupa in the soil, the former feeding on the cane roots. The adult feeds upon young mango leaves. It may be found sometimes in abundance hiding away for the winter under bark or in any sheltered crevices, and it emerges again in March. *M. blandus*, Fst., is a small dull grey species which feeds upon the young leaves of cane and maize and is very destructive to young plants (cf. *Pachnephorus*).

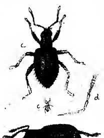


Fig. 262.—MYLLOCERUS SETULIFER. [I. M. N.]

Eremninæ.—Phytoscaphus triangularis, Oliv. (Plate XXVII, fig. 5). is a small brown weevil, with lighter markings found commonly feeding on leaves. *Amblyrrhinus poricollis*, Boh., is a similar and smaller insect, frequently found feeding upon the small leaves of mango, litchi and other fruit trees.

Hyperinæ.—Hypera includes two common species found breeding upon lucerne (*Medicago sativa*) and Senji (*Melilotus indica*). The green grub feeds exposed upon the leaf ; a parchment-like cocoon is made on any part of the plant and from this the imago emerges. The weevil is far more destructive than the grub, eating into the shoots and causing them to wither. The species concerned are *H. varians*, Hbst. (Fig. 261). and *H. medicaginis*, Mshll. ; they have an active season in the cold weather only, disappearing into hiding in March or April, the weevils living over until the next cold weather in concealment.

Cleoninæ.—Lixus brachyrrhinus, Boh., breeds freely in the cultivated Amaranths grown as vegetables, the grubs being found in the stems. The weevils can be found on the plants in the rains. *Atactogaster finitimus.* Fst. (*Leucomigus antennalis*, Fst.). is stated to be injurious to cotton and gram in South India (Ind. Mus. Notes. Vol. IV, p. 112). and is a common insect in Madras.

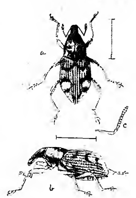


Fig. 263.—ATACTOGASTER FINITIMUS. [I. M. N.]

Xanthochelus superciliosus, Gyllh. (Plate XXVII, fig. 9), is the large grey weevil found feeding abundantly upon the leaves of ber (*Zizyphus jujuba*).

Hylobiinæ.—Paramecops farinosa. Wied., is the weevil so commonly found on the Ak (*Calotropis* spp.). It is greyish in colour but is covered in a white mealy efflorescence. The eggs are laid in the rind of the Ak fruit, the little grubs boring into the soft tissues and feeding on the developing fibre and young seeds. The full grown grub reaches a length of half an inch, and pupates in a compact cocoon formed of the delicate fibre (known in commerce as "kapok"). Ten days after, the adult emerges, and feeds on the leaves of the Ak plant. The weevils are very common and widely spread where this plant grows.

Cyladinæ.—Cylas formicarius, F.—The best account of this insect is found in the Queensland Agricultural Journal for August 1900 (page 176). Mr. Tryon there gives a thorough account of the species, with a complete bibliography. He discussed its origin, a matter still of doubt, but as the two first describers, Fabricius and Bohemann, both obtained it from India, there is some ground for believing it to be a native of South India, spread gradually over the tropics. A short account of this insect will be found in Indian Insect Pests. Eggs are laid on the sweet potato tuber or rootstock, the larvæ tunnelling into the tissues and boring through them ; pupation takes place inside and the weevil feeds also on or in the tuber. The stages are well shown in Plate XXVI, and the weevils may be found throughout India, being often destructively abundant.

Apioninæ.—The genus *Apion* includes a vast number of tiny beetles with straight antennæ and marked sexual differences, found almost over the globe. The colours are black, brown, blue, red or metallic. A number of Indian species are known, but the discrimination of species is very difficult. *Apion gagatinum*, Mots., is a common plains species on grass. *A. strobilanthi*, Desb., is described from seeds of *Strobilanthus* in Sikkim, an unusual habit for a member of this genus (Ind. Mus. Notes, Vol. II, p. 32). Another species lives in the stems of jute in India.

Attelabinæ.—The genus *Apoderus* contains the weevils in which the head and sometimes the prothorax is drawn out into a long neck (Plate XXVII, figs. 7, 8). These weevils prepare cases of green leaf; the leaf is cut across near the base, the cut reaching from each margin to the midrib or crossing the midrib from one margin only; the leaf is then folded longitudinally, and the tip rolled in; an egg is laid and the rolling process continued till the leaf, up to the cut, forms a compact cylindrical mass, consisting of tightly rolled and folded leaf blade, with the egg in the centre; no silk or gum is used and the insect works with legs and jaws in folding and packing the leaf: the roll is left adhering to the remainder of the leaf, the egg hatches and the grub feeds on the leaf inside the roll. The roll subsequently dries and falls off with the pupa inside. We figure the case of *Apoderus blandus*, Schonh., made on Sissu. Eggs laid on 25th June, hatched on the 28th, the larvæ pupated by the 30th and weevils emerged from the 3rd to the 7th July; the life-history is thus a very brief one and there are apparently two broods during the rains, the second being a hibernation brood in which the larva remains for the winter in the case. *A. tranquebaricus*, Fabr., in South India rolls the leaf of the country almond (*Terminalia catappa*) and the habit has been observed in a number of species in the sub-tropical zone of India. Over 30 species are known in India, in the genera *Apoderus*, *Attelabus*, and ***Rhynchites***.

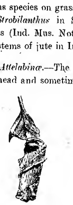


Fig. 264.—LEAF CASE OF APODERUS BLANDUS, MAGNIFIED.

Balaninæ.—*Balaninus Bomfordi*, Fst., eats into the unopened buds of the banyan tree and feeds on the inside; with their very slender curved beaks they make neat punctures and many buds wither. The larvæ are found in the fleshy receptacles of the fig, which they destroy so that the fig falls off. We figure this species, which represents the group in the plains, and *B. C. album*, Fabr., found in Eastern Bengal (Plate XXVII, fig. 17).

Cioninæ.—*Cionus hortulanus*, Fourc., Var. *major* is a "cold weather" species in the plains, breeding only on *Celsia coromandeliana*; the shiny grubs feed openly on the buds and look like caterpillars; they pupate in a delicate horny cocoon, made of anal secretion, on the plant. There are, as a rule, about three broods yearly in Pusa, from February to April, the weevils then seeking shelter. They are usually very abundant, one of the most noticeable of the cold weather forms. In the Himalayas at 7,000 feet this weevil breeds on *Celsia* from May to October. *C. albosparsus*, Fst., has been found in Bombay and others occur in the sub-tropical zone.

Alcidinæ.—A sub-family confined to the Old World and mainly occurring in the tropics. It consists of *Alcides* with 242 species recorded up to 1906 and *Acærus* with one. The group has been listed by Bovie (Genera Insectorum 1907). Of the former 26 species are Indian. The species of which anything is known have been reared from larvæ boring in the shoots of plants. *Alcides leopardus*, Ol. (Fig. 261), is the species most commonly found, known throughout the plains; its larva bores in the shoots of cotton, destroying them, and pupating in the tunnel near the bark. The pupal period is short (4 days) and the weevil rests within the tunnel for some days after.

A. collaris, Pasc., is a larger species, the prothorax red-brown, the elytra black with white spots, which is found in sweet-potato fields in the plains. *A. fabricii*, F., has reddish-brown elytra with cream stripes, and a black and cream coloured prothorax; it has been found in widely scattered localities. *A. bubo*, F., is the weevil whose larva breeds in Agathi (*Sesbania*) in South India and is a serious pest. Its eggs are greenish white, flattened and of nearly round outline, laid in holes in the stems of the young plants and covered with gelatinous material.

The life-history occupies six weeks; many larvæ are found in the same plant, which dies, and the loss in young plants is extensive.

Cryptorhynchinæ.—Pachyonyx quadridens, Chevr., is found breeding in the dhak plant (*Butea frondosa*) in Northern India. *Cryptorhynchus* contains the mango weevils of India, of which *C. gravis*, Fabr., is the common form in Eastern Bengal and Assam, *C. mangiferæ*, F., in South India and Ceylon. Both breed in the stone of the mango, the eggs being laid in the young fruit, the larva on maturity eating through the pulp and emerging to pupate in the soil. There is but one brood yearly of the former and the weevils remain dormant from July or August to the following March—April in concealment in the ground and in or on the bark of trees.

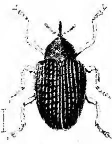


Fig. 265.—CRYPTORHYNCHUS GRAVIS.

Desmidophorus contains several sub-tropical species, *D. hebes*, Fabr., also occurring in Behar, where it is occasionally found in abundance on garden Hibiscus.

Zygopinæ.—Phænomerus sundevalli, Boh., is a small linear beetle, resembling an elongate rice weevil, found in the plains. *Metialma* includes two species, *M. scenica*, Pasc., and *M. balsaminæ* Pasc., the latter having been reared from larvæ found boring in the stems of balsams; the larva tunnels in the soft tissues and pupates in a cocoon formed of fibres twisted into an oval shape.

We figure a *Phylaitis* (Plate XXVII), common in the stems of malvaceous plants, which attacks cotton severely and specially tree cottons. It was a serious enemy to tree cottons in Behar and is destructive in South India, the larvæ boring in the stems, forming a thick swelling and eventually so weakening the plants that they break off or die. Its distribution appears to be a limited one, as it is not a widespread pest of cotton.

Calandrinæ.—*Rhynchophorus* includes the common Palm Weevil of India *R ferrugineus*, F. (*R. signaticollis*, Chevr.), which breeds in the toddy palm (*Phœnix sylvestris*) and in the cocoanut palm (*Cocos nucifera*). The eggs are laid in the soft tissues at the base of the leaf sheath, at a wound or at the cut made by the toddy drawer; the larvæ tunnel through the tissues in all directions and, when mature, make a cocoon of twisted fibres. This insect is one of the more important pests of India and much has been written of it in Ceylon where it is of still greater importance. (Figs. 268, 269.)

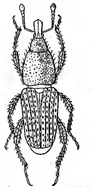


Fig. 266.—Calandra oryzæ. × 10.

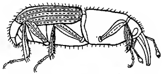


Fig. 267.—Calandra oryzæ. × 10.

Calandra (Sitophilus) is a genus of two species of world-wide occurrence. *C. granaria*, L., is of a uniform deep redbrown colour, the prothorax with oblong punctures; the metathoracic episternum is very narrow with a single row of punctures. It is wingless. *C. oryzæ*, Linn., has two fulvous patches on each elytron, the punctures on the prothorax are rounded and closer together, the metathoracic episternum is wider and has two rows of punctures. It is winged, the weevils flying readily. The latter is the common Indian species, of which much has been written, but little is known.

Odoiporus glabricollis, Gyll., is the common weevil whose larva breeds in the stems of the plantain (*Musa sapientum*) The black weevil is to be found on or in the plant and is quite common. (Fig. 260.)

Polytus mellerborgii, Bh., is a tiny dark coloured weevil found breeding in decaying plantain stems.

Cercidocerus bimaculatus, Boh., is a black species in which the antennæ have a very expanded truncate club; it is found rarely in tropical India.

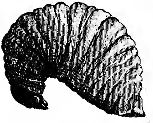


Fig. 268.—RHYNCHOPHORUS FERRUGINEUS LARVA.

This family also includes the large forms such as *Cyrtotrachelus dux*, Boh., & *C. longipes* found in sub-tropical India, which are the most striking Curculionids of the Indian fauna. In the latter the male has very long forelegs; they feed on the juice of bamboo shoots and the eggs are also laid there, the larvæ tunnelling in the shoots and making the usual fibrous cocoon of this group.

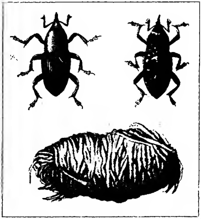


Fig. 269.—RHYNCHOPHORUS FERRUGINEUS. [I. M. N.]

Collecting.—Weevils are simply collected on their foodplants and require no special methods. The rarer species are obtained by "beating" bushes, and it is advisable to remember that they often sham dead and fall to the ground when the plant is shaken. Larvæ are to be found in every possible part of the plant and practice enables the collector to discern swollen twigs or branches in which larvæ are found. They are not difficult to rear and almost any part of a plant is worth investigating for weevil grubs. The rarer species are obtained in this way and there is no better collecting method than to search systematically among wild plants. Benzene is the best killing agent and the weevils keep well until required to be set.

BRENTHIDÆ.

Antennæ straight, nine or eleven-jointed. A horizontal rostrum, usually long. Tarsi pilose below. Body elongate.

A family closely allied to the *Curculionids* but usually of more elongate and linear form. They are usually bare, shining, of dull browns and ferruginous tints. The males in some cases have large curved mandibles or expanded and toothed fore femur and tibia. The habits of but few are known and none of these appear to be Indian. In general, they are wood-boring or found in decaying wood. They are chiefly tropical and well represented in the forests of the East. There are two sub-divisions :

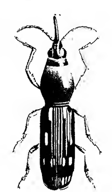


FIG. 270.—ORYCHODES SP. × 4.

Antennæ eleven-jointed. *Brenthinæ*
,, nine ,, *Ulocerinæ*.

There are about twenty recorded Indian species, but the family has been greatly neglected. Several species are common in the plains, in some of which there appears to be a considerable amount of sexual differentiation in respect of the head and rostrum. The family is listed by Von Schonfeldt in Genera Insectorum (1908), who enumerates 10 species from India exclusive of Burmah and Ceylon, the small number of species recorded being apparently due to errors of geography in the earliest describers of species.

Calodromus Mellyi Guer., *Calliparcius foveatus* Senna, *Cerobates canaliculatus* Mo., *Symmorphocerus cardoni* Senna, *Prophthalmus delesserti* Pow., *P. obscurus* Pow., *P. potens* Lac., *Baryrhynchus miles* Boh., *Eupsalis truncatus* Boh., *Orychodes pusillus* Oliv., are the known Indian species.

SCOLYTIDÆ.

Rostrum short or absent. Antennæ short, elbowed, clubbed. Tarsi apparently four-jointed, filiform, third joint entire or bilobed, not elongated.

A family closely allied to some of the Curculionidæ in structure but distinct in the almost total absence of the rostrum and in their habits. Most are elongated and cylindrical, of small size and of the dull brown or black colour common to beetles which live in darkness. The antennæ are short, sometimes with twelve joints (funicle 1, scape 7 club. 4), sometimes with as few as three. (Fig. 193.)

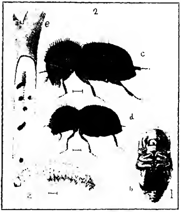


Fig. 271.—XYLEBORUS FORNICATUS (I. M. N.)

Owing to their peculiar habits a great deal has been learnt of these insects since they are of extreme importance in forestry. Nearly all are borers in woody tissues, but few living in green tissues (the Scolytid that bores in the shoots of the common plant *Vinca rosea.* in the Western Hemisphere does not seem to occur in India though the plant does). Owing to the destruction they cause in forestry, the group has been extremely carefully studied elsewhere and the student will find full details in works on the forest insects of America and Europe. Their peculiar habits, especially in regard to sex, some being polygamous, some monogamous, the extreme ingenuity of their system of tunnelling and the fact that in some their food consists not of wood but of the fruiting bodies of certain fungi, which they themselves (hence called ambrosia beetles) cultivate with care, makes them a group of especial interest. They are, however, practically wholly forest insects. and occur almost entirely in the sub-tropical hill forest areas of India. No species are of agricultural importance, and the typical wood and bamboo borers of the plains are *Bostrichidæ* and not *Scolytidæ*.

The family include monogamous species and species which are polygamous; in the first, the female prepares a bore, then goes out and returns with a mate and subsequently makes tunnels at right angles to her original bore; each tunnel contains an egg and the male remains in the original tunnel. Such tunnels may be in one plane. since there is only one branching. and they may be contained in the bark only. In polygamous species, the male makes the first burrow, the females gathering in it and each making a tunnel from it; from these they make other tunnels, in each of which eggs are laid. Of these tunnels, some must be horizontal and some vertical and they extend into the wood since the narrow bark will not accommodate them. Thus in the first case. the borings are simple, only a coupling burrow (made by the female) and larval burrows at right angles (the larvæ on becoming beetles burrowing straight out to the bark); in the second, they are complex and consist of the coupling tunnel. the mother tunnels at right angles each made by one female, and at right angles in another plane the egg-tunnels; the system become so complex that air holes may be made to the bark by the mothers. In the different species the tunnels vary and the individual kinds are too complex to be noticed here.

The life-histories of many species are known and something is known of Indian species. Works on forest insects must be consulted for details. The chapter on Scolytidæ in Gillander's "Forest Entomology" (1908) should be consulted as giving an excellent resumé of the family. Over 50 'Indian' species have been described by Motschulsky, Blandford, Eichhoff and others.

The family is divided into two according to the tarsi :—

First tarsal joint shorter than the remainder together ..	*Scolytinæ.*
First tarsal joint = the remainder	*Platypinæ*

The *Scolytinæ* are divided into three sub-families, *Scolytini*, *Hylesini*, *Tomicini* ; all are represented in Indian forests. We may mention *Xyleborus perforans*, Woll., reported some years ago as attacking beer casks in India and which is known to live in sugar-cane in the West Indies, where it however attacks only diseased cane. The mother beetle makes a tunnel in which she lays eggs, the larvæ feeding on fungus hyphæ in the cane and not boring themselves. (See Blandford, Kew Bulletin, September, 1890, April, 1892.) *X. fornicatus*, Eichh., attacks tea in Ceylon (Indian Museum Notes, III, 57), and Assam ; its presence is associated with a fungus and there is reason to believe it is also an "ambrosia" beetle, cultivating the fungus for its own food and for that of its larvæ. Of the *Platypinæ*, *Platydactylus* (Ecotopterus) *sexspinosus*, Motsch., was reported as burrowing in the stalk of rice in Burmah. This observation has not been confirmed. The species is described by Blandford in Indian Museum Notes (III, p. 64). *Platypus pilifrons*, Chap., and *P. sordidus*, Wlk., occur in the plains. The *Platypinæ* are in some cases known to be ambrosia beetles.

STYLOPIDÆ.

These aberrant *Coleoptera* are of uncertain position. We are not aware that any are definitely recorded, but Horne, in his notes on the habits of Indian Aculeate Hymenoptera, states that many females of *Polistes hebræus* contain *Stylops* in the second abdominal segment. It is recorded that the genus *Polistes* is the host of *Xenos*, a genus in which the female is wingless and larviform, the male winged and active ; that *Xenos* occurs in *Polistes hebræus* in India has been ascertained recently, the male wasp showing the pupal cocoon projecting from its abdomen, as a brown body which on dissection proved to contain a dead male of *Xenos*. The hibernating females are also infested and in March, the female *Xenos*, in the body, yields abundant small active larvæ which apparently pass from the queens to their young in the new nests. The first brood of wasps is thus infected and from them males have been reared. The female is a mere egg-producing sac which lives always in the wasp and is fertilised there by the male, which is winged. Infection occurring thus in the nest, there is apparently a constant succession of broods; some wasps contain as many as three *Xenos*, which in their mature or pupal condition are readily visible as brown bodies attached at the junction of two abdominal segments, This *Xenos* appears to be a marked check on *Polistes hebræus*, a large percentage being infested in some cases.

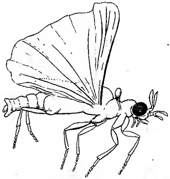


Fig. 272.—MALE OF XENOS FROM POLISTES HEBRÆUS. × 12.

LEPIDOPTERA.

(Butterflies and Moths.)

Two pairs of large wings, of nearly equal size; the body and wings densely clothed in hairs and scales. Antennae of varied form, usually simple, with a varying arrangement of cilia, never serrate or lamellate or bristle-shaped. Mandibles absent (except Micropterygidae) mouthparts in the form of a tubular proboscis and palpi

Metamorphosis complete, the larva with short biting mouthparts, with two to five pairs of suckerfeet, adapted to living openly on plants or, more rarely, in them. The imago obtains its food from flowers or plant sap, the larva is herbivorous on or in plants, very rarely predaceous. In a large number the imaginal life is brief and no food is taken; in others it is longer; in all, the larval life is comparatively long and active.

Lepidoptera are recognisable readily in practically all stages and the characters are sufficiently distinct. They include insects of small size as well as insects with an enormous wing span, though of no great weight. The immense weight of chitin which characterises the giants among the beetles is here replaced by an extensive wing area, so large that some of the largest moths measure as much as eight to twelve inches across the wings.

There is a far greater uniformity of structure, facies and appearance in this order than in any other and, except in cases where members of other orders are deliberately mimicked, there can be no doubt as to the immediate recognition in the field of a butterfly or moth both in the larval, pupal and imaginal stage. Eggs are of three main types, the upright domeshaped butterfly egg, the rounded moth egg, the flat scale-like egg of the Microlepidopteron, the first two being often sculptured, the last reticulate. Larvæ are of one type, with a distinct head, with three pairs of legs and from two to five pairs of suckerfeet, with a chitinous plate behind the head, with a number of chitinous tubercles on each segment, which bear hairs. It is impossible to give characters by which one may recognise every form of larva, but it will assist if we mention some of the more prominent. Caterpillars with rows of spiny processes (Plate XXVIII, fig. 1) are *Nymphalidæ;* rather flattened "onisciform" larvæ, densely clothed in short hair are *Lycænidæ* (Plate XXXII), smooth caterpillars with a distinct neck are *Hesperiidæ* (Plate XXXIII), smooth caterpillars with smooth processes on the head or body are *Papilionidæ;* uniformly hairy caterpillars are *Arctiidæ* or *Eupterotidæ*, smooth caterpillars with few short hairs are *Noctuidæ* (Plate XXVIII, figs. 2—5); semi-loopers are also of this family (Plate XXVIII, fig. 13), whilst true loopers with two pairs of suckerfeet are *Geometridæ;* large caterpillars with an anal horn or a bulbous prothorax (Plate XXVIII, fig. 6) are *Sphingidæ;* hairy caterpillars with erect tufts are *Lymantriidæ* (Plate XXVIII, fig. 8), with lateral tufts are *Lasiocampidæ* (Plate XLVI). Caterpillars, smooth or spiny, in which the lower surface is a gliding surface are *Limacodidæ* (Plate XXVIII, fig. 10). Smaller caterpillars with few short hairs and hooks on the suckerfeet in a circle are *Pyralidæ* (Plate XXVIII, fig. 7), *Tineidæ* (Plate XXVIII, fig. 10) or *Tortricidæ* (Plate XXVIII, figs. 11, 12). Large caterpillars with hair-bearing processes are *Saturniidæ* (Plate XLII). Figures of all these types are given below, and a glance through the figures will show that there are distinct types but that they do not clearly delimit the families as other characters do, and vary very greatly in the limits of a large family like *Noctuidæ* in accordance with habits.

The pupa is brown, the appendages usually firmly fastened to the body and not free, the parts not movable with the exception of some of the abdominal segments; an important character is the nature of the hooks at the apex of the abdomen which secure the pupa in the cocoon and enable the moth to emerge. Resistance to weather is the object of the Lepidopterous pupa and it is of a firmly chitinised and well protected kind. As a rule, a cocoon of silk, alone or with extraneous matter, or of agglutinated soil, is formed before pupation.

There are three devices in the imago for locking the wings, both pairs being functional in flight. (1) The frenulum, a stiff bristle or group of hairs on the base of the anterior margin of the hind wing which engage in a catch or group of bristles (*retinaculum*) on the lower surface of the forewing; this is found in most *Lepidoptera*. (2) Expanded basal area of anterior edge of hindwing; found in *Rhopalocera; Lasiocampidæ*, *Pterothrysanidæ, Endromidæ, Chrysopolomidæ, Arbelidæ, Perophoridæ, Ratardidæ, etc.* (3) The *Jugum*, a membranous or spine-like process from the base of the hind edge of the forewing, passing under the hindwing and holding it between the jugum and forewing; found in *Hepialidæ and Micropterygidæ.*

CLASSIFICATION.—It is unfortunate that no uniform system of classification has yet been universally adopted which can be readily followed in all systematic works and text books. For the Indian student, it is necessary to remark that we are unable to follow the classification and order of the Moth Volumes of the Fauna of India, since the author is now producing a revised classification which must sooner or later be adopted in the Fauna of India Volumes. For the present time, it would be more convenient to follow the Fauna; a year hence the later classification may have replaced it and, in this dilemma, we have followed the order of the new classification. (Hampson, Catalogue of Lepidoptera Phalænæ, Vol. I.) This is also confusing as it is not the order followed in Sharp's Insects; but we have tried to reduce the inconvenience by listing the new order with page references to the Fauna of India Volumes. It is, however, desirable to retain the old division of Butterflies and Moths and we have done so. (In the list, families named in italics are not known in India.)

	No.	Vol.		No.	Vol.
1. **Syntomidæ.**	10	I, p. 209.	18. Psychidæ.	12	I, p. 289.
2. **Arctiidæ.**	24	II. p. 1.	19. *Heterogynidæ.*		
3. **Agaristidæ.**	25	II, p. 148.	20. Arbelidæ.	14	I, p. 314.
4. **Noctuidæ.**	26	II, p. 160.	21. *Argyrotypidæ.*		
5. **Pterothysanidæ.**	21	I, p. 430.	22. Ratardidæ.		I, p. 493.
6. **Lymantriidæ.**	22	I, p. 432.	23. Cossidæ.	13	I, p. 304.
7. **Hypsidæ**	23	I, p. 495.	24. Lasiocampidæ.	20	I, p. 402.
8. **Sphingidæ.**	5	I, p. 65.	25. *Endromidæ.*		
9. **Cymatophoridæ.**	7	I, p. 177.	26. *Chrysopolomidæ.*		
10. **Eupterotidæ.**	4	I, p. 41.	27. *Perophoridæ.*		
11. **Notodontidæ.**	6	I, p. 124	28. *Megalopygidæ.*		
12. **Geometridæ.**	30	III, p. 138.	29. Limacodidæ.	19	I, p. 371
13. **Saturniidæ.**	1	I, p. 12.	30. *Dalceridæ.*		
14. **Bombycidæ.**	3	I, p. 31.	31. Neocastniidæ.	12a	IV, p. 471.
15. **Brahmæidæ.**	2	I, p. 29.	32. *Castniidæ.*		
16. ***Ceratocampidæ.***			33. Nymphalidæ.	Butterflies.	I.
17. **Uraniidæ.**	27-28-29	III p. 107 137.	34. Satyridæ.	,,	I.

	No.	Vol.		No.	Vol.
35. Pieridæ.	Butterflies.	II.	44. Thyrididæ.	18	I, p. 352.
36. Lycænidæ.	,,	II, III.	45. Pyralidæ.		IV. p. 1.
37. Ericinidæ.	,,	I.	46. Orneodidæ.		
38. Papilionidæ.	,,	II.	47. Pterophoridæ.		
39. Hesperiidæ.	,,	III.	48. Sesiidæ.	8	I, p. 187.
40. *Euschemonidæ.*			49. Tortricidæ.		
41. Zygænidæ.	11	I, p. 228.	50. Tineidæ.		
42. Callidulidæ.	16	I, p. 322.	51. Hepialidæ.	15	I, p. 316
43. Drepanidæ.	17	I, p. 326	52. *Micropterygidæ.*		

We give the diagnosis of each family in terms of the venation as in Hampson; but it is not possible, unless one already knows the venation well, to simply use this diagnosis; to the systematist familiar wit [illegible] ms used, the diagnosis is useful for reference; to the general student nothing but careful study with the Fauna and Catalogue of Lepidoptera Phalænæ will make this diagnosis of any use and we refer the worker who wishes to identify specimens to these volumes. For this reason also we give no explanation of the venation or terms, since the whole art of using them depends on a knowledge of the interpretation put on them by systematists, which is quite different from that of ordinary people.

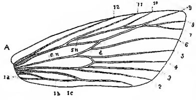


Fig. 273.—VENATION OF COSSID FOREWING, HEPIALID HINDWING. (*After Hampson.*)

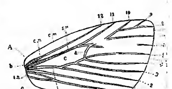


Fig. 274.—VENATION OF LEPIDOPTERA. (*After Hampson.*)

RHOPALOCERA.—*Butterflies.*

Day flying insects, the antennæ knobbed at the tip. No frenulum, the costal nervure arched at the base.

The butterflies are familiar to everyone from their large size, their bright colours, their sunshine-loving habits. Whilst most are clearly distinct from the moths, these distinctions are not easily defined, and the fundamental distinction lies in the wings. In *Rhopalocera*, the hindwing has a projecting shoulder at the base, which fits under the forewing, thereby securing the rigidity of both wings together. This fact can be expressed by saying that the costal nervure is arched, as it is to support this shoulder. In *Heterocera*, the wings are held together by the frenulum, a bristle or tuft which projects forward from the hindwing and fits into a pocket on the under surface of the forewing, or the jugum, a projection from the posterior edge of the forewing. The costal vein is not arched and moths are said to be frenulate or jugate. The distinction between moths and butterflies is a useful one but hardly an accurate one and there is little need to discuss its value.

The butterflies are eminently a group that love the densely forested hills where vegetation is abundant and varied, where rain falls abundantly, producing a continual greenness. Few are found in the dry cultivated plains, where foodplants are scarce, where there are long periods of drought and little shelter. Those that are of wide distribution are grass-feeding species or species that have widely scattered foodplants among the wild shrubs or flowering plants, or which feed on a cultivated plant. The ideal place for butterflies is the lower slopes of the hills well clothed with forest, with a sub-tropical climate and an elevation not over three to four thousand feet. Here butterflies attain their greatest development and few places are richer than such localities in India. Fortunately these insects may be omitted in this place. Our concern is only with the few very common ones likely to be found generally distributed over the plains and which are abundant in the bare cultivated areas.

Almost all butterflies have a similar life-history. The eggs are laid on the foodplant, singly or in clusters. The larvæ have five pairs of suckerfeet, and feed openly on the leaf on plant tissue. Pupation takes place on the plant, openly, with no cocoon. The eggs are rounded, upright, with the micropyle at the top as in the greater number of the moths.

They are laid singly as a rule, a few (*e.g.*, *Delias eucharis*) laying them in rows. The egg hatches, the larva eats the egg shell and commences to feed on the living plant tissue. Most are solitary, a few (Pierids) gregarious. Nearly all have the usual cylindrical form, tapering a little at head and tail; some are fusi-form, short, robustly built and unlike a caterpillar (*Lycænidæ*); others have a conspicuous neck (*Hesperiidæ*) and in some the head is noticeably small (*Pieridæ*). The body is clothed with erect spiny processes in many, in others with long procumbent appendages, or with long processes on head or anal segment.

When full-fed the larva pupates openly on the plant; it may simply hang by the tail (*Nymphalidæ*), or be fixed by the tail with a thread round it; in the latter case, it may be horizontal or with the head upwards (*Lycænidæ*), or hang freely in the loop, head upwards (*Pieridæ* and *Papilionidæ*). Finally it may be free in leaves rolled or drawn together (*Hesperiidæ*).

The length of the life-history varies and the number of broods in the year differs with the species; these insects are dependent for their season on their foodplant and the caterpillar is found when the young shoots are put out or when the young leaves are available. For most this period covers the latter half of the rains and two months after, but many breed also in the early hot weather, which is the spring for many plants. Two to three broods a year is the most usual and the imagos live for long periods before they are able to lay eggs. Hibernation takes place in every stage even the egg and, in the plains, many hibernate as imagos. The relative length of the stages varies according to the stage in which hibernation or æstivation is passed, either of the four being prolonged. The imago as a rule is longlived and feeds upon the nectar of flowers.

In the plains, butterflies are found practically all the year and most are two brooded; there is a brood in July-August, produced by the eggs laid in June and a later brood from the butterflies that emerge in August. This latter hibernates and may live through the hot weather if its foodplant be not available. The student must bear in mind that this does not apply to all the plains species, nor to the group as a whole; some plains species breed freely in March-May if their foodplant be available, as, for instance, those on irrigated crops or fruit trees; nor does this apply to the abundant hill and forest species; though much is written about these, we are not aware that any author has yet dealt with this point fully for any family of butterflies in India.

The butterflies are extremely well known, and far more is written about them than other insects in India. Their life-histories have been worked out to a far larger extent than have those of other families and a great mass of information exists about this group. Bingham's volumes in the Fauna enable every species to be identified and fix the nomenclature, we trust, for many years. De Niceville and Marshalls' Indian butterflies gives an account of the species of the Indian region, and it is necessary only to deal here with the species common in the plains; the student will find ample details in the above volumes. For *Pieridæ* and *Papilionidæ*, the second volume of Butterflies in the Fauna should be used or the many papers published in India. A synopsis of the *Hesperiidæ* has been recently published in Genera Insectorum, but Elwes and Watson's papers and those of Doherty must be consulted. The pages of the Journal of the Bombay Natural History Society contain abundant information and most readable articles; the descriptions of caterpillars by Bell, Davidson, Aitken, and de Nicéville are of extreme value. For descriptions as for all identification and synonymy, the volumes of the Fauna of India by Bingham are taken as the latest authority and these are indispensable to students of this sub-order, who wish to be able to identify their specimens. The student should consult also the late Mr. L. C. H. Young's papers on the common butterflies of India in the Bombay Journal for 1906-7, the beautiful plates of which will enable him to identify the plains species of *Nymphalidæ*: these are being continued by Mr. T. R. Bell.

For the recognition of our few species, it is unnecessary to discuss the fundamental structural details that underlie the family distinctions. There are six families of which one (*Nemeobiidæ*, *Lemoniidæ*, *Erycinidæ*) we may omit.

The ***Nymphalidæ*** have the forelegs reduced in both sexes and not used for walking. They include the majority of the butterflies. The ***Lycænidæ***, Blues and Hairstreaks, are small insects, the male tarsus of only one joint, long. The *Pieridæ*, Whites and Sulphurs, have all the legs similar, the claws bifid or toothed. The *Papilionidæ*, Swallow Tails, are the large butterflies and are distinguished by having all the legs well developed with large simple claws. The *Hesperiidæ*, Skippers, are smaller, the antennæ hooked rather than knobbed, the body robust, the flight quick.

Students of Indian Insects who may have made collections in this sub-order will perhaps be surprised that so few species are mentioned: we may remind them that we have attempted to deal with every family in due proportion and were we to discuss each family in proportion to what is known of them, then the section on this sub-order would be a very large one. The species mentioned are literally those common in the cultivated plains of India and a student who knows the little there is here knows as much, relatively, of these insects as is necessary to him.

Collecting.—The common species mentioned below are often obtainable best as caterpillars on their foodplants; perfect specimens can then be reared and properly set. As with moths, specimens caught on tour can be put up in triangular papers and packed in boxes. Relaxing and setting requires care and is best deferred till a number can be properly relaxed and set at one time. A little Acetic acid should be put in the relaxing box to avoid discolouration. As with all caterpillars. "blowing' is the best process for preservation. Except in *Lycænidæ* there is little to be done in the plains compared with other groups and we would recommend no one to devote time to this group, beyond rearing and becoming familiar with the common forms.

NYMPHALIDÆ.

Forelegs reduced, the male with one, the female with five tarsal joints without claw. Pupa suspended from the tail. Larva usually with spiny processes on head and tail or on each segment.

There is a characteristic facies in the species of each family except this, which renders the identification of this family easy in the field, any butterfly not evidently one of the latter groups, falling probably into this one: in the few instances when this fails, the legs must be examined. Nymphalids are usually large butterflies of bright colouring with distinctly sunshine-loving habits in all but one subfamily, the *Satyrinæ*. Many have warning colouring associated with unpleasant taste and there is good reason to believe that birds and insectivorous animals will refuse these; others deliberately mimic these, and thereby escape the fate that their edibleness should bring on them; a few have distinctly Deceptive Colouring (page 90), while the colours of a number bear no obvious interpretation in our eyes but may have a protective value; it is perhaps unnecessary always to seek out the

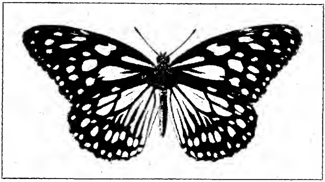


Fig. 275.—DANAIS LIMNIACE.

value of the colour scheme in insects and it would be nice to think that butterflies are simply beautiful to be beautiful; it is, however, at the least likely that with beauty is combined some measure of practical use, and we may not unreasonably believe that the diverse colouring of most Nymphalids blends generally with the light and shade of a mass of vegetation particularly when they are regarded from the birds' elevation and not from our level on the ground. Thaxter's article in Transactions of the Entomological Society, 1903, p. 553, is worth perusal in this connection. Many butterflies of this family exhibit what has been called "bird-misleading colouration," the large distinct colour-marks on the wings diverting the bird's aim for the head or body and so enabling the pursued to escape with only a bit taken out of its wing.

The life-history so far as known is in general the same throughout the group. Eggs are laid singly on the foodplant, the larva that hatches feeding on the green tissues of the foodplant. While there is no definite means of identifying a Nymphalid larva in every case, the majority are of cylindrical form, with a distinct head, the body provided with processes which are usually branched. The pupa is suspended from the hind end without a girdle. The number of broods varies but is usually two, rarely four or more. The remarks under the sub-order apply to this family. Very few are pests; *Melanitis ismene* Cram. on rice, *Ergolis merione* on castor, and very rarely *Junonia almana* in swarms of other caterpillars are the only ones known. Like other Lepidoptera, these suffer from the attacks of parasites, both Hymenopterous and Dipterous, and the principal check on their increase, next to food supply, is this factor. It is difficult to rear any species without getting parasites.

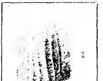


Fig. 276.—DANAIS LIMNIACE EGG

The family is divided into six sub-families, which need not be noticed here as so few of the many species come within the limits of our fauna. The student will find fuller details in Bingham's volume of the fauna of India or de Nicéville's volumes.

Danainæ. *Danais* is perhaps the most common genus, with three species found throughout the plains in suitable localities. Like *Euplœa*, the male has two protrusible brushes of hair at the apex of the abdomen and a pouch on the hind wing, connected with the production of scent.

Danais plexippus, Linn., is discussed by de Nicéville as *D. genutia*, Cram. The butterfly is figured there; it is orange-brown, with black margins containing white spots, the veins heavily marked with black. Its larva is black, each segment with streaks and spots of white and yellow, and there are three pairs of black processes, on the meta-thorax, third

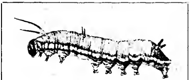


Fig. 277.—DANAIS PLEXIPPUS FULLGROWN LARVA.

abdominal and ninth abdominal segments. Wild Asclepiads are its food and the pupa is suspended as is usual in the group. The pupa is green with metallic silvery and golden spots.

Danais chrysippus, Linn., is similar the veins not marked with black; its larva is grey with five black and a yellow band on each segment and a yellow lateral stripe; there are three pairs of processes, of which the pair on the meta-thorax are the longer; the chrysalis is light-green or pink, with golden spots on the anterior (lower) end, and a golden black-bordered line round the posterior (upper) end; the foodplant is the common Ak (*Calotropis* spp). De Nicéville and Marshall speak of this as "the commonest and most widely spread of all the Indian butterflies." In the plains it is common throughout the year, abundant especially in November.

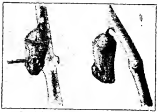


Fig. 278.—Danais limniace pupæ.

Danais limniace, Cram., is black with very faintly blue markings as shown in fig. 275. It is likely to be confused with *D. septentrionis*.

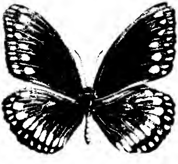


Fig. 279.—Euplœa core.

Butl., in which the markings are smaller and bluer. Its larva, which has but two pairs of processes, is yellow-white with transverse black bars and a yellow lateral line; the pupa (fig. 278) is green with golden spots at the anterior end, and a serrate metallic band at the posterior end. It also feeds on *Calotropis* and Bell found it on *Dregea volubilis*. Like the last it is common throughout India and, with it, one of the commonest insects met with in Indian gardens. *Euplœa* is represented by several species, but one of which is sufficiently widespread to deserve mention here. *E. core*, Cram., is dark brown, paler towards the outer margin with a double series of white spots in this paler area. The caterpillar is described as lilac above, deep brown below, with transverse black bands to each segment; there are four pairs of processes, an anteriorly directed pair on the mesothorax, and others on the metathorax, third and ninth abdominal segments. The food-plants are said to be Oleander, *Ficus bengalensis*, *Ficus glomerata* and *Cryptolepis pauciflora*. The distribution in India is given as "suitable localities throughout the continent." The male of this species, if captured living, will protrude the anal brushes, tufts of buff hair on conical fleshy processes, a pleasant aromatic odour being diffused from them.

Satyrinæ are regarded by Hampson as a distinct family, the base of vein 12 of the forewing being dilated; they include the dusky butterflies found under trees which have that curious flitting flight and the habit of suddenly settling with closed wings and turning to an angle with the perpendicular, suggesting a blowing leaf. Mr. Green has remarked of one that it turned at an angle so as not to throw a shadow. They are characteristic insects and in their habits clearly distinct from the sunshine-loving *Danainæ*.

Mycalesis includes the common *M. perseus*, Fabr., which is taken to include *M. blasius*, Fabr., the former being the dry-season form, the latter the wet-season form. The butterfly is a deep brown, with one distinct and one indistinct ocellus above and with seven ocelli on the hindwing and two to four on the forewing below, these ocelli being scarcely visible in the dry-season form, in which the under surface is darker. There is a narrow fascia of purple-white across both wings and numerous white lines on each side of the ocelli. The arrangement of the ocelli on the hindwing distinguishes it from the nearest ally, *M. mineus*, Linn., the former having the posterior three only in line, the latter the posterior four. The species is widely distributed in India in the plains in suitable localities and is found almost throughout the year. The larvæ are described by Davidson and Aitken, feeding on grasses and also on rice. Betham records the attraction mohwa refuse and jaggery have for these, as for other butterflies, in India; the attraction presumably lies chiefly in the spirituous matter left in the refuse, just as the rum is the attraction in the entomologists "sugaring" mixture. We figure the curious pupa and imago of *Orsotriæna meda*, F., found on rice in the very moist areas of India.

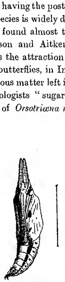


Fig. 280.—ORSOTRIÆNA MEDA, PUPA. [F. M. H.]

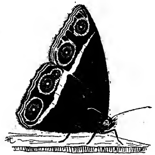


Fig. 281.—ORSOTRIÆNA MEDA. [F. M. H.]

Lethe europa, Fabr., is the large dark brown butterfly common in the plains of North India; the upperside in the male has two white spots on the forewing, in the female has a broad white oblique band: in both sexes there is a series of black ocelli on the lower surface of the wings towards the margin, with light lines on the inner and outer margins. The larva and pupa are described by Davidson and Aitken; the former is green with a single short horn on the head and feeds on dwarf bamboo (Journ., Bombay N. H. Soc. V, p. 350).

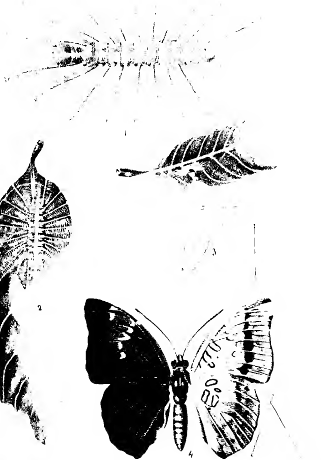
Ypthima contains one widespread species (*Y. hubneri*, Kby.) out of the 22 known as Indian, as well as two which occur in the plains, *I. baldus*, Fabr., and *Y. inica*, Hew. They are smaller dusky butterflies with yellow ringed ocelli on the wings, and appear to be common only in the moister parts of the continent. The larva of *hübneri* is described by de Nicéville as green, about one inch long, with two divergent processes from the anal segment pointing backwards. It feeds on grasses.

Melanitis ismene, Cram., which is taken to include *M. leda*, is the large deep brown butterfly so common round the trunks of trees; two or more are commonly to be seen flying round the trunks of large shady trees, their dusky colouring and quick settling making them difficult to see. The upper surface is uniformly coloured in brown, with two large black spots near the apex of the forewing containing each a white spot and some ferruginous marking. The under surface is extremely variable, marked in tints of brown, yellow and ferruginous and, especially in the dry-season form, alike in almost no two specimens. The resemblance to a dry leaf is extraordinarily close, and the resting attitude, with the wings folded, the body rigid so as to incline the wings at an angle to the ground, bears out this appearance. The larva feeds on rice and grasses, being green, rough and wrinkled, with two processes on the head and two on the terminal segment; by day it clings closely to the leaf of the rice, and is extremely difficult to find; it feeds at night. The butterfly appears to be common throughout the plains and is found through the cold weather, there being, as a rule, two broods in the year, the butterflies of the second living till the following rains. (Plate XXIX.)

The *Morphinæ*, also known as *Amathusiinæ*, are large butterflies often of great beauty, found wholly in the moist hill forest areas of the Himalayas, Assam, South India and Burmah. Not one species comes within our plains fauna. The group is a small one, intermediate between *Satyrinæ* and *Nymphalinæ*, with 11 Indian genera. Stichel has recently listed the known species in "Genera Insectorum."

Nymphalinæ.—The largest of the sub-families, with the greater number of the plains species. They are typically butterflies found flying in the sunshine, settling with the wings open and usually of bright colour. The larvæ are cylindrical and usually provided with processes or spines.

Charaxes is represented outside the hills by *C. fabius*, Fabr., a large black butterfly with a series of yellow spots forming a band across both wings, with a series of smaller yellow spots near the margin, and with the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hindwing produced into two slender tails. The larva is figured by Davidson and Aitken (Journ., Bombay N. H. Soc. V, p. 278), who found it feeding on tamarind. The student should consult these excellent papers for information as to the larvæ of butterflies, and since this publication should be in every Library, we have forborne from reproducing the figures. Equally the list of foodplants of Kanara butterflies in the Transactions of the Asiatic Society of Bengal (Vol. LXIX, p. 187) should be consulted.

Euthalia. Out of 20 species, two of the Indian forms can be considered as widespread in the plains and as likely to be found. *E. garuda*, Mo., is a deep brown insect, the female paler than the male, both with dark loops near the base of the wings and, on the forewings, a series of five white spots from the costa near the middle. There is an outer series of black spots on the hindwing and the under surface is paler with nearly similar markings. The larva is figured by de Nicéville and was found by him feeding on mango. It is perhaps the most beautiful and striking of all the butterfly eaterpillars and, while not abundant, is to be found on the mango in most parts of India. (Plate XXX.)

E. nais, Forst., is smaller, the upper side bright tawny, with black bands and dots. De Nicéville remarks that it thrives best in open and moderately dry country; the larva is similar to that of the above species and is described by Moore.

Neptis eurynome, Westw., includes forms separated by de Nicéville and others, but regarded by Bingham as the same. On the latter basis, this species is widespread in India. The upper side is black, with white spots in three oblique lines across both wings, with an outer series of smaller ones on the forewing. The under surface is a deep rich red-brown, with the markings larger and confluent. The larva is described as green with processes on the sides of the third, fourth, sixth and terminal segments, and spines on the head.

In the next species, *Rahinda hordonia*, Stoll., the markings are on the same plan but larger, confluent, and a bright tawny colour; the butterfly is widespread, its larva feeding on Acacia and Albizzia (see Bell, Davidson and Aitken, Journ., Bombay Nat. Hist. Soc. X, p. 250).

Cyrestis thyodamas, Boisd., is the sole common species of this genus and is noticeable chiefly from its remarkable larva found feeding on *Ficus* *nemoralis* and *F. glomerata*. The student should consult the papers of de Nicéville and F. W Mackinon in Volume XI of the Journal of the Bombay Natural History Society for beautiful figures of butterfly larvæ, including this remarkable species.

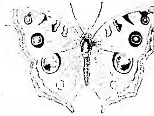


Fig. 282.—JUNONIA ALMANA.

With *Danais*, *Junonia* is the common genus of butterfly known to all in India. The numerous forms are abundant in gardens, and to those who appreciate their beauty, it is worth while growing the blue-flowered *Stachytarpheta indica*, which is in itself so dull and uninteresting, on account of the myriads of Junonias which will visit it in autumn. We figure *Junonia almana* ; the six Indian species are all common in the plains. Bingham gives the following key to them :—

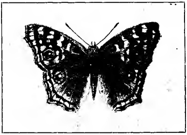


Fig. 283.—JUNONIA LEMONIAS.

a. Upperside ground-colour brown.

a^1. Forewing without yellow spots or discal band on upperside .... *J. iphita.*

b^1. Forewing with yellow spots or a whitish discal band on upperside.

a^2. Forewing with yellow stops on upperside......... *J. lemonias.*

b^2. Forewing with an oblique whitish short discal band on upperside .... *J. orithya*♀.

b. Upperside ground-colour yellow...................... *J. hierta.*

c. Upperside ground-colour : forewing black, hindwing blue .... *J. orithya* ♂.

d. Upperside ground-colour pale lavender-grey or brown . . *J. atlites*.

e. Upperside ground-colour rich orange-yellow .... *J. almana*.

The larvæ are cylindrical with rows of spines or processes, and usually dull in colour. All feed on wild plants, but *J. almana* has been known to join other bands of swarming caterpillars and destroy rice fields on a large scale. The larva of *J. orithyia* feeds on a common weed, *Justicia* sp. (Plate XXVIII, fig. 1) and the larva of *J. lemonias*, on bariar (*Sida rhombifolia*).

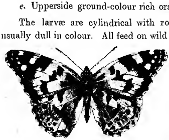


Fig. 284.—VANESSA CARDUI.

Vanessa is represented by *V. cardui*, Linn., the "Painted Lady" of England, found throughout the world, and rarely in the plains, and by *V. indica*, Herbst. The larva is like that of Junonia ; the first feeds on *Argemone mexicana*, the second on *Zornia* and *Blumea*.

Hypolimnas is remarkable on account of the striking sexual differences exhibited. The female in each case mimics a Danaine butterfly. *H. bolina*, Linn., mimicking *Euplœa*, *H. misippus*, Linn., mimicking *Danais chrysippus*. The males are deep black, with a large

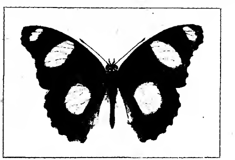


Fig. 285.—HYPOLIMNAS MISIPPUS MALE.

white patch in each wing, which has metallic blue reflections; in *H. bolina* the edges of the wings show traces of the markings characteristic of the female, but in *misippus* the two sexes are totally distinct in colour. The larvæ are of the usual form, with rows of spines. Both species are common in the plains, and the student may be on his guard against regarding the females as Danaids on superficial characters.

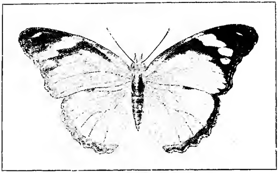


Fig. 286—HYPOLIMNAS MISIPPUS, FEMALE.

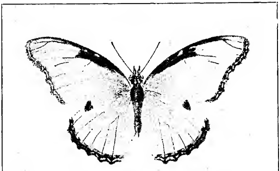


Fig 287—HYPOLIMNAS MISIPPUS, DIMORPHIC FEMALE.

The beautiful oak leaf butterflies of the genus *Kallima* deserve mention, though only one can doubtfully find a place in our plains fauna. Every butterfly collector is familiar with these, as every visitor to the Museums of London or Calcutta should be. *Kallima inachus*, Boisd., is the common hill form, found wherever there is sufficient moisture and forest, as at Pachmarhi and in Orissa. *Kallima horsfieldi*, Koll., is treated by Bingham as distinct, and as including several forms regarded by de Nicéville as distinct; it occurs at elevations of 2,000 feet and upwards in Western and Southern India and may be the Western form of *inachus*. Davidson and Aitken describe and figure the larva, and state that it feeds on *Strobilanthus*. *Cethosia cyane*, Dr., is perhaps the most notable butterfly of Bengal: it is a curiously tame species and we have caught it in our fingers at *Duranta*: the larva is stated to feed on passion flower (Moore). *Atella phalantha*, Dr., is a small tawny butterfly with black markings; de Nicéville says of it: "This species is one of the commonest Indian butterflies, occurring throughout the year in the plains and in suitable seasons in the outer Himalayas up to 8,000 feet." Davidson and Aitken describe the larva, which is stated to feed on *Flacourtia* and *Salix*.

Ergolis includes the widespread *E. merione*, Cram., whose larva feeds on castor leaf. (*Ricinus communis*.) The butterfly is not common, flying among the foliage of dense trees and this species is one of the few that breeds on a plant of economic importance. (Plate XXXI.)

Of the *Acraeinæ* but one can be included here, the little tawny *Telchinia violæ*, Fabr., whose larva feeds on the wild passion flower (see Davidson and Aitken). It was reared in Bengal on *Hibiscus cannabinus*. The larva is spiny and may be protected by its unpleasant taste.

The *Libytheinæ* include only the genus *Libythea* wholly absent from the plains.

NEMEOBIIDÆ (*Erycinidæ*, *Lemoniidæ*).

Forelegs fully developed in female, imperfect in male.

This family includes species almost wholly confined to the forest-clad hills. They have somewhat the appearance of Lycænids, with short tails on the hind wing in some cases. *Dodona eugenes*, Butl., has been reared from a green flattened larva, feeding upon grasses and bamboo (Mackinon). *Abisara echerius*, Stoll., is the only species found in our area; Davidson and Aitken reared the larva, and describe it as being light-green, flat, very broad in the middle, tapering to both ends; the pupa is closely attached to the leaf by the tail and a girdle. The total number of species in India, Burmah and Ceylon is twenty.

PIERIDÆ.

Legs fully developed, claws bifid or toothed. Hind wing with vein 1a present. Larva smooth or with fine pubescence. Pupa with a girdle, upright or horizontal.

These butterflies are of moderate size, coloured in white, yellow, orange and black; the colouring is vivid, noticeable and probably warning. The majority of the family and practically all our common species are instantly recognisable as Pierids in the field and the family is a very distinct one. Males and females differ little save in colouring, while dry-season forms of both sexes are often darker than wet-season forms.

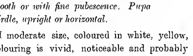


Fig. 288.—PIERIS BRASSICÆ.

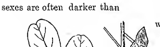


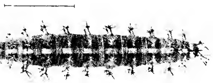
Fig. 289.—CATOPSILIA PYRANTHE PUPA ATTACHED TO TWIG OF CASSIA.

There is little to comment on in the life-history. Eggs are laid in groups or singly, upright sculptured eggs, constricted near the apex, of a dull yellow white colour. The larvæ are usually coloured in yellow or green with black and are smooth, or have a short dense pubescence often with grandular hairs bearing each a drop of fluid. They commonly feed in company, a row eating steadily away at the epidermis of the foodplant together. Our common species feed on *Cassia* and

PLATE XXXI.—ERGOLIS MERIONE.

THE CASTOR BUTTERFLY.

Fig 1. Egg, seen from above. x 18.
„ 2. „ lateral view. x 18.
„ 3. Young larva, dorsal view.
„ 4. Full-grown larva, dorsal view.
„ 5. Second and third abdominal segments of larva.
„ 6. Section of third abdominal segment to show arrangement of processes.
„ 7. A single process.
„ 8. Chrysalis, dorsal view.
„ 9. Imago, female, dorsal view.
„ 10. „ „ ventral „



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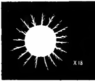

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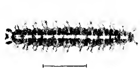

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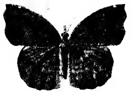

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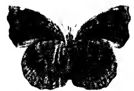

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allied *Leguminosæ*, on *Capparis* and *Capparidaceæ*, on *Brassica* and *Cruciferæ*, and on *Loranthus*.

Pupation takes place after the larva has attached the anal prolegs to the pad of silk and fastened the thoracic girdle, the pupa being horizontal or upright. The pupæ are green, cryptic in form and colour. The butterflies are day-flying and very noticeable, some being strong fliers which visit flowers, others fluttering in low vegetation and grass. They appear to hibernate as imagines and where the foodplant is available, lay eggs early in the year at the onset of the hot weather. The number of broods is at least two and in some cases as much as six or more. A great deal has yet to be learnt of the occurrence of some species during the year, and the matter is by no means a simple one. We may mention *Pieris brassicæ*, Linn., as an instance, there being reason to believe that this butterfly migrates from the hills for the cold weather and early hot weather, spending this period in the submontane districts of the Himalayas for instance, breeding on cultivated *Cruciferæ* and returning to the hills for the summer there. This is by no means definitely ascertained, but it is in strong contrast, for instance, with such a species as *Terias hecabe*. Linn., which is a constant breeder in the plains, wherever food is available, and so long as the weather is warm enough. Only one species is in any degree destructive, *Pieris brassicæ*, Linn., being a pest to cabbages and other garden Cruciferæ, in sub-Himalayan tracts.

The larvæ are the hosts of parasitic *Hymenoptera* and a very large proportion are destroyed in some seasons.

Bingham has recently revised the Indian forms in the Fauna of India, with the help of de Nicéville's manuscript of his proposed volume in the butterflies of India. Only 91 species are recorded in all, and this is probably a smaller number than any other author would allow. The tendency to split species and indefinitely multiply them is deplorable, and it is to be hoped that Bingham's commonsense views will be accepted as final.

Leptosia xiphia, Fabr., is common in the plains, a small white butterfly, with rounded wings, the apex of the forewing and a large sub-apical blotch black. It is a graceful butterfly of delicate build, found in the jungle: the larva is recorded on *Capparis*.

Delias eucharis, Dr., is one of the most common and striking butterflies of the plains; it is white above; the veins lightly or heavily marked with black; below, the apex of the forewing and hindwing are bright yellow between the veins, with an outer series of bright vermilion blotches between two black bands; the red looks as if dabbed in with a brush and stands out extraordinarily sharply and crudely. This beautiful insect flies about in the sun and is one of our most striking butterflies. Aitken records its habits of laying eggs in rows and not singly as do most butterflies. Its larva feeds on the mistletoe (*Loranthus*), growing on trees and is readily reared.

Anapheis (Belenois) *mesentina*, Cram., is white with fuscous markings; the larva feeds upon bagnai (*Capparis horrida*), and the butterflies are common throughout the year. The pupa is green with yellow spots; it has a spine on the vertex, one on the dorsum and a lateral pair.

Pieris is represented sporadically by *P. brassicæ*, Linn., the common "cabbage white," which is found within 100 miles of the Himalayas in Eastern Bengal, Behar, the United Provinces and Eastern Punjab. This insect is sometimes extremely abundant, coming in the cold weather in numbers and breeding freely on cruciferous plants. Its sporadic appearances are due either to the action of parasites which ultimately destroy a very high percentage of the larvæ and check the insect apparently for some years, or to its sporadic migration from the hills into the plains. *Ixias pyrene*, Linn., is yellow with black and orange covering the apical half of the wing. Its larva feeds on *Capparis sepiaria* with that of *I. mariamne*, Cram.; both are common in India in the hills as in the plains. *Appias libythea*, Fabr., is a white butterfly with dark markings at the edge of the wing in the male, over the apical half in the female. The larva was reared by Davidson and Aitken on *Capparis horrida*.

Catopsilia includes the two common white butterflies, *C. crocale*, Cram., and *C. pyranthe*, Linn. Both feed freely upon the weed Chakaur (*Cassia occidentalis*), the latter also upon the Indian laburnum (*Cassia fistula*) and are common throughout the year.

Colias croceus, Fourc. (*fieldi* Men), is a beautiful orange species, the wings edged with fuscous and with the undersurface yellow. It is one of the common butterflies in the fields in the dry hot months.

Terias is perhaps the most common of the Pierids, the little yellow butterflies with black edges to the wings which are so abundant throughout the plains. *T. hecabe*, Linn., has been reared upon *Cassia tora* and probably feeds on several species of Cassia. Watson refers to it as having at least four broods yearly, and in favourable places possibly twelve. It has been reared in Bengal also on Jainta (*Sesbania aculeata*). The oval elongate egg is greenish white, laid singly on leaves. The larva is green, with a lateral white stripe, and transverse wrinkles ; they pupate (after twenty days larval life) with the head downwards, the body in the girdle, and their colour is green or brown according to the leaves they are on or among. The pupal period varies from five days to twenty-five days. This species is variable in markings and is not easily distinguished from *T. venata*, Mo., *T. libythea*, F., and *T. læta*, Boisd., which also occur in the plains.

Coletis amata, Fabr. (*Teracolus cypræa*) is orange above, with many dull black markings, and yellowish below. The larva is striking, as it feeds in company on the leaves of *Salvadora persica :* the full grown larva is cylindrical, yellow green, the head and body with tubercles bearing hairs, at the end of each of which is a drop of fluid. These feed in a row, eating away the epidermis and gradually moving down the leaf. They are common where this plant grows in the drier parts of India. *Coletis* (Teracolus) *etrida*, Boisd., may also be expected in the plains.

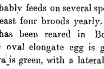


Fig. 290—Coletis amata.

MIGRATION.

To those who live in tropical countries, the migration of insects will suggest at once the flight of vast-swarms of locusts, perceived as a cloud on the horizon growing larger as they approach till the sky is dark with them and they pass on overhead or alight for a while before resuming flight. In locusts we see the phenomenon in its most striking and exaggerated form, one in which the magnitude of the insects impresses us most distinctly and gives a perhaps exaggerated idea of the actual numbers of insects concerned.

We have in the Bombay Locust (*Acridium succinctum*, Linn.) a most striking example of an insect that is at once an ordinary non-migrating grasshopper and a migrating locust; this insect occurs over a large part of India in small numbers as an ordinary member of the fauna not occurring in specially large numbers. In certain areas it becomes extremely abundant in occasional years, packs into swarms and migrates over long distances. In this case, the change of habits is associated with a change of colour, the insect becoming suffused with brilliant red. Normally this occurs in November or early December when the insect migrates; yet specimens with the normal colouring are found elsewhere or when in small numbers right through until June and no colour-change takes place. One would hesitate to attribute the colour-change to the mere change of habits did one not also feel that the habit of migration is one that must exert a profound effect on the insect itself. We have elsewhere suggested that the red colour facilitates migration in swarms since it renders the swarm visible at a distance and enables stragglers to come up (Mem., Agric. Dept., India, Entom. Vol. I, No. 1); that the commencement of the migration induces the colour-change is striking, but the observation of this insect leads one to believe it to be true. The question that naturally arises is, why do locusts migrate? Why does this impulse come upon them and impel them to move in swarms over long distances, or even, as the Bombay Locust does in its early flights, to fly solitarily and steadily in one direction at night till they have covered a hundred or as much as 200 miles. We believe it is due to two motives: first the need of food; second, the need of finding satisfactory places to lay eggs. In the year 1903, the Bombay Locust gathered in immense quantities in the forests of the Western Ghats before the winter; this was probably for food since only in these forests would they find a sufficiency of green leaves; afterwards they moved out in swarms, as they have done before and after; this was, we believe, to enable them to lay eggs in places where grass abounded rather than trees, since the hoppers live in moist grasslands among low vegetation. The same two motives would appear to apply to the Migratory Locust which first migrates in search of food and has a brilliant "migration" colour, and then moves further in search of sandy wastes and gets a protective yellow "Sand colour" when it is going to lay eggs: only in this species the hoppers too have a migrating habit since they are born and live, not in the midst of plenty in rainy places as does the Bombay Locust-hopper, but in arid lands where the drought-resisting bushes afford less food. If then these views are correct, the migrating habit has arisen in the latter species as a necessity of food getting and reproduction, and is so habitual as to be instinctive, while in the former it arises only in the adult when it is surrounded by many of its kind and the assumption of the habit produces peculiar colour-changes as a physiological result. Out of all the many grasshoppers in India, we know of this habit in only two species and one may wonder why it should occur in these only; but it is necessary to think back one stage and wonder why these two should reproduce so abundantly. This we cannot answer, save by saying that Nature is full of variety and makes one species prolific, another always a rarity. There is reason to believe that, like the

Bombay Locust, others migrate when abundant, the instinct to do so moving them when many are together. Thus the Central Asian locust, *Pachytylus cinerascens*, occurs in India sparsely, but is a well known migrating locust in places where it is more abundant, and we believe it would be so in India were favourable conditions to make it abundant.

Scanty records exist of the migration of other insects and we can mention a few of these. From time to time, one reads in newspapers of a swarm of butterflies having been seen flying steadily in a particular direction; we have seen this in the case of a West Indian skipper (*Calpodes ethlius*) which was extremely abundant; de Rhé Philippe in his paper on the butterflies of Lucknow, mentions it in the case of a Lycænid (*Polyommatus bœticus*, Linn.) which he says migrates annually to the hills in great numbers in the early hot weather (Jo. Bo. Nat. Hist. Soc. XIV, p. 481); Dudgeon (Jo. Bo. Nat. Hist. Soc. XIV, p. 147) has remarked on migrations of *Catopsilia crocale*, Cram., and *Anapheis* (*Belenois*) *mesentina*, Cram., with small numbers of other species which he has observed in the Kangra Valley, where they are said to be not unusual. He found they flew steadily in one direction and that both sexes were present.

G. C. Nurse also has observed a migration of *Catopsilia pyranthe* at Deesa in August, and states that it has been seen to occur every year for three years back. (Jo. Bo. Nat. Hist. Soc. XIV, p. 179.) Other instances will be found in Indian literature and it is probable that these cases are associated with food supply, not so much for the actual migrating insect, as for its young. Other recorded cases include the migration in swarms of dragon flies (*Odonata*), though such cases are rarer. Such a case is mentioned by Morren, where *Libellula depressa* migrated in vast numbers in Belgium (A. N. H. II, Vol. 13, p. 239). Howard (The Insect Book, p. 331) mentions seeing a "migrating army of Cockroaches, incalulable in number," crossing the street in Washington and apparently moving from an undesirable building to others, the motive being, he considers, the desire of the females to lay their egg cases in a place that might afford food to their abundant young.

Finally we may mention the fly *Sciara*, whose larvæ are recorded as moving in a solid mass steadily in one direction: this phenomenon occurs in some European and American species, where it is well known.

PAPILIONIDÆ.—*Swallow tails.*

Legs fully developed, claws large and simple. Hindwing with vein 1a. absent. Pupa with girdle, fixed at tail, head upwards. Larva with or without processes, not hairy.

These insects include the finest and most striking of the butterflies, but they are almost wholly confined to moist forest areas and but three species are common in the plains. Those who wish to see Papilios should visit the hills of Assam, Burmah and Indo-China, the few that occur within our limits not representing the group adequately. Bingham records 129 species in the Fauna of India, Vol. II.

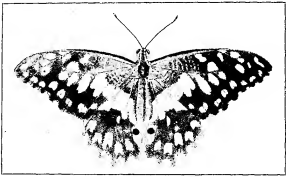


Fig. 291—PAPILIO DEMOLEUS.

Papilio demoleus (*erithonius*), Linn., is common throughout the plains, a moderately large butterfly coloured in black with yellow blotches and an indefinite eye spot on the hindwing; its larva is found upon the lime, orange, bael (*Ægle marmelos*), bawchi (*Psoralea corylifolia*) and other *Rutaceæ*. the larva is smooth and thickset, and feeds on leaves; it is at first a dull brown with a large irregular white

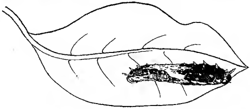


Fig. 292—YOUNG LARVA OF PAPILIO DEMOLEUS ON ORANGE LEAF. × 2.

blotch on the upper surface; whilst it has this colouring, it feeds on tender leaves and rests openly on the leaf where it resembles a bird's excrement: at the third moult, it becomes green; apparently it is now too large to mimic bird's excreta and it adopts a cryptic colouring, green with purple brown oblique bands. It is now somewhat snake-like in appearance and by some observers is regarded as being so to an extent that may be protective. The larva on being irritated extrudes a forked yellow process from the prothorax, which gives out a scent: presumably this is a protective device. Pupation takes place on the plant. The number of broods yearly does not appear to be known; there are certainly two in the months preceding the rains and apparently two during and after these months, but there is not any apparent regularity.

P. pammon, Linn., is not distinguishable from the above as a larva, but the butterfly is distinct. Unlike *P. demoleus*, it occurs in more than one form. The two species are destructive to young Citrus trees and while *demoleus* appears to be most common, both occur throughout India.

P. aristolochiæ, F., is the only other common species: its larva is deep velvety brown, with a cream coloured band across the abdomen, and with short blunt reddish processes; the chrysalis is of peculiar form, resembling a torn leaf; the foodplant is the cultivated climbing *Aristolochia*, as well as the wild *Aristolochia indica* found as a field weed.

LYCÆNIDÆ.—*Blues, Coppers, Hairstreaks.*

Forelegs slightly reduced. Male tarsus of one joint, with one claw. Precostal nervure absent. Pupa usually attached to leaf, with a girdle. Larva fusiform, smooth and without long hairs.

The family is distinguished readily by its appearance in nearly all cases, being of small to moderate size (among butterflies), the hindwings often with little tails, the colouring usually blue or grey above with metallic reflections, grey or white below with many dark spots and, often, coloured ocelli.

The colouring of the undersurface is distinctly cryptic, blending beautifully with the prevailing light and shade of dry grass when the butterfly sits on a grass stem with folded wings.

The life-history presents features which are characteristic of the family (Plate XXXII); the eggs are less dome-shaped than in most

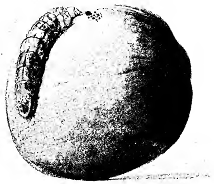


FIG. 293—VIRACHOLA ISOCRATES, LARVA ON GUAVA FRUIT.

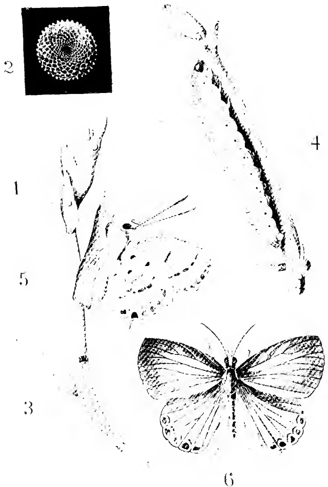
Rhopalocera, white or bluish and reticulate; they are laid singly on the foodplant. In most cases the larva is flattened, oval, the legs and prolegs under the body; the general form is that of a woodlouse ("Onisci-form"); there is commonly a dense covering of very short hairs, though some are smooth and a few tuberculate with bristles. In many forms, a secretion much sought after by ants exudes from an opening at the hind end, and each species has its special attendant ants. *Curetis* larvæ have a peculiar process bearing a tentacle at the end of which are hairs; this tentacle is whirled round rapidly when the larva is alarmed, presumably with the object of frightening off enemies. *Liphyra* has a still more remarkable larva, a description of which occurs in the Fauna of India Volume.

The larvæ are vegetarian in nearly all cases, feeding on leaves or buds and living exposed on the plant, their form and cryptic colouring rendering them inconspicuous.

PLATE XXXII.—CATOCHRYSOPS CNEJUS.

THE HAIRSTREAK.

Fig 1. Egg on shoot.
,, 2. Egg. x 50
,, 3. Larva. x $1\frac{1}{2}$.
,, 4. Larva. x 4
,, 5. } Imago. x 2
,, 6. }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The pupa is rounded, humped at the thorax, constricted behind the thorax, and flattened below, usually smooth. It is attached by the cremaster and usually by a girdle.

The butterflies are day-flying, fluttering about in grass and low herbage, the larger forms being strong fliers. Hibernation in this group is commonly in the imago stage in the plains and there are two or several broods in the year, depending upon food-supply. None are serious pests except *Virachola isocrates*, which works havoc in plantations of pomegranate.

Lycænids have not been collected in India to the extent that other butterflies have, and there are fewer data in the case particularly of distribution. The species common in the plains are far less well known, and we have mentioned only those species we are certain are widely spread, a very small number considering the large number of forms that exist in India. Bingham, who has revised the family in the Fauna of India, divides them into seven sub-families. The student should see these volumes (Butterflies, Vols. II, III) where the known species are described and their larvæ.

Spalgis epius, Westw. (fig. 292), is notorious on account of its (larval) habit of devouring mealybugs; it is distinctly not vegetarian as are its allies, but lives among colonies of the larger mealybugs and feeds on them; it has been found with *Phenacoccus iceryoides*, Gr.: the larva is short and thickset, with a thick coating of white mealy wax adhering to its short stiff hairs; its appearance is exactly like that of the clustered

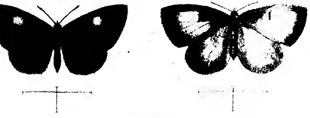


Fig. 294—SPALGIS EPIUS. LEFT, MALE: RIGHT, FEMALE.

bugs and only careful examination distinguishes it. The head and feet are concealed, the body below is greenish. The larvæ when full fed walk about, settle down and pupate, emerging after 9 days as butterflies. Aitken figures the larva and pupa (Journ., Bombay Nat. Hist. Soc., VIII, p. 485), but the student may be cautioned against taking his remarks seriously as to the resemblance of the pupa. In this as in 8 other genera the girdle is absent, the pupa attached only by the cremaster. The butterfly is widespread, but perhaps not abundant, being dependent for its food on this and other mealybugs. Mr. Green was the discoverer of the carnivorous habit of the larva, which was confirmed by Mr. Aitken, and we have since reared the butterfly from the mealybug we mention. The butterfly (fig. 294) is violet-brown above. with a square white spot in the forewing, and greyish white below with brown lines on both wings, without ocelli.

Chilades includes two plains' species; *C. laius*, Cram., which is blue above and without colour or metallic scales on the marginal spots below and *C. trochilus*, Frey., which is dull black above, the marginal spots with metallic scales and orange colour. The larva of the former is described as feeding on the leaves of lime and pomelo: de Nicéville says it can be " confidently looked for in any part of India where any trees allied to the orange grow." The larva of the latter is described by de Nicéville, as feeding on *Heliotropium strigosum*, *Zornia diphylla*, and on indigo in Behar.

Zizera includes the smallest known butterflies with *Z. gaika*, Tr., only six-tenths of an inch across the wings; some of these are abundant in the plains on low vegetation, while here and there one finds them in profusion on a patch of grassland. De Nicéville considered there were but four species in India, though he listed all the species mentioned as distinct to the number of thirteen. *Z. maha*, Koll., is the largest, with the upper surface of the male silvery blue with a black border, the female blue to black. The flat green larva was found on *Oxalis corniculata*. *Z. lysimon*, Hubn., is small, the wings above violet blue in the male, greyish brown in the female and having the spot near the middle of the discoidal cell below, which is present also in *Z. maha*, but absent in the next two. This is taken to include the common *Z. karsandra*, Mo., which breeds freely on lucerne (*Medicago sativa*) in the plains where this is grown, and probably also on wild leguminous plants. Davidson and Bell reared it on a vetch, *Zornia diphylla.*

Z. gaika, Trim., has two spots on the costa of the forewing below, one on either side of the discocellular spot. It appears to occur in grass and low herbage throughout India, though best known from hill localities. *Z. otis*, Fabr., has no costal spot below and is the last of this genus which de Nicéville regarded as distinct. Accepting this view, the species is widespread in India; he records rearing it on *Alysicarpus vaginalis* in Calcutta.

Lampides is also widespread in India, *L. elpis*, God., light metallic blue above, rather less so than *L. celeno*., Cram., (*ælianus*, Fabr.) which is milk white above. The former feeds on the cardamom (*Elettaria cardamoma*) where this plant grows, the latter on the Dhak (*Butea frondosa*) and on *Heynea trijuga*. For the accurate identification of these insects as for particulars of this family, the student should consult the third volume of de Nicéville's Butterflies of India, and Bingham's volume II of the Butterflies in the Fauna of India. An account of *L. elpis* will be found in Indian Museum Notes, Vol. I, p. 11.

Catochrysops is regarded by de Nicéville as containing three species, while he lists nine. *C. strabo*, Fabr., has a "distinct small dusky costal spot between the disco-cellular and discal bands on underside of forewing; eyes hairy." While the others have not these characters, *C. cnejus*, Fabr., has two nearly equal black spots at the anal angle of hindwing above, while *C. pandava*, Horsf., has but one such spot, in each case in the male. The first of these has been reared once from *Vigna catjang*. the second from *Cajanus indicus*, and other common pulses (Plate XXXII), the third from Cycads. All are common in the plains and may be captured readily. *Tarucus theophrastus*, Fabr., is the commonest of all these butterflies and is readily found as a larva on the ber (*Zizyphus jujuba*). The flat green larvæ eat off the epidermis much as a snail feeds and gradually denude the branches of leaves: the smaller bushy plants are preferred and one may frequently see a number of the little butterflies clustering on one little bush to sleep. De Nicéville, in commenting on the number of species made by some writers, urges the breeding of this species in large numbers on this common foodplant; the views of two authors as to what constitutes a species are rarely identical; it is evident that every species varies, that given a large number of variable specimens it is difficult to group them if there are any intermediates, and finally that, since this depends entirely on the judgment of the individual, the views of variable individuals will differ; we must then have recourse to the only test, namely, breeding from eggs laid by distinct females; if we find that out of one female's eggs we get all the varieties, then all fall into one species; when this does not occur, but one batch of eggs gives only one variety, and another a second, we are further towards the truth, and by further breeding and judicious attempts at coupling, we can separate our species with some distinctness. This is what requires to be done for many forms of Rhopalocera, and will eventually have to be done in the case of many species of other groups, when these come to be as well known as the butterflies.

Castalius ethion, Doubl., and *C. rosimon*, Fabr., are also recorded by Bingham as widespread in India, feeding also on the ber.

Polyommatus bœticus, Linn., is referred to by de Rhé-Philippe as migrating yearly in swarms from Lucknow to the hills in the early hot weather (Journ. Bombay Nat. Hist. Soc. XIV, p. 488). Probably many more species have this habit in sub-Himalayan localities and the cold weather fauna of the Gangetic plain may be partly composed of such migrating insects. De Nicéville records rearing this on the flowers and pods of *Crotalaria calycina*.

Virachola isocrates, Fabr., is the most important economically of the butterflies, perhaps the only one that is constantly and regularly injurious. The male is a beautiful glossy violet blue above, the forewing with an indistinct ochreous spot; the female is violet brown above, the ochreous spot more distinct. This insect has been described and figured several times; the student should read the delightful account of Westwood, reprinted in de Nicéville's Butterflies of India, III, p. 478. The larva feeds on the fruit of guava, pomegranate, etc. *V. perse*, Hewits., also occurs throughout India, both sexes being black above, with blue (not metallic) on the basal area of forewing and disc of hindwing. Aitken records it as feeding on the fruit of the Ghela (*Randia dumetorum*).

The following species, in addition to those referred to above, may be looked for in the plains :—

Neopithecops zalmora, Butl.
Megisba malaya, Horsf.
Cyaniris puspa, Horsf.
Azanus ubaldus, Cram.
,, *uranus*, Butl.
,, *jesous*, Guer.
Lycænesthes emolus, God.
Talicada nyseus, Guer.
Everes argiades, Pall.
Nacaduba ardates, Mo.
Lampides bochus, Cram.
Tarucus plinius, Fabr.
Curetis thetis, Dr.
Aphnæus vulcanus, Fabr.
,, *elima*, Mo.
Tajuria longinus, Fabr.
,, *jehana*, Mo.
Deudorix epijarbas, Mo.

HESPERIIDÆ.—*Skippers.*

Forewing with all the veins separate. Front tibia with a pad. Claws short and thick with an empodium. Antennæ hooked beyond the club. Larva smooth, slightly flattened, with a distinct neck. Pupa in a fold of the leaf.

These butterflies are recognisable, as a rule, by their stout build, quick jerky flight and, when at rest, by the curious manner in which the wings are held at an angle to the body. They are of moderate size and only rarely of bright colour, a dull brown being the commonest tint, though some are bright orange and brown. The body is stout, the wings short ; the head is large, with large eyes, the palpi three-jointed, porrect or upturned. The legs are equally developed, the middle tibiæ with one, the hind tibiæ with two spurs. There are certain secondary sexual marks

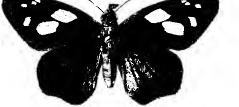


Fig. 295—GANGARA THYRSIS (I. M. N.).

on the males including a costal fold on the forewing closed during life and containing silky hairs, a stigma on the forewing and glandular patches of specially modified scales.

The life-histories of a small number are known and have the main features the same (Plate XXXIII). Upright eggs are laid singly on the foodplant, which hatch to caterpillars with five pairs of suckerfeet. The larvæ are usually smooth and elongate, tapering evenly to either end. the head large and often with a paired process, the prothorax distinctly compressed behind the head, giving the appearance of a neck. The body is slightly flattened, the inter-segments not constricted and the suckerfeet are flat; the whole structure enables the caterpillar to remain closely pressed to the leaf during the day and the colours are commonly green or whatever tint best agrees with its foodplant. None exhibit warning colouration, or terrific devices, and they appear to depend upon their cryptic form and colour. Some live between the folds of a leaf, others openly on the leaf and most are nocturnal feeders. The foodplants include grasses (*Gramineæ*), palms and species of *Scitamineæ*. The pupa is cylindrical, the hind end tapering and terminating in a spine; it lies in a fold of the leaf or between two leaves fastened together with silk; the cremaster is attached in the usual manner to a silk thread or pad and, in some common species, the pupa is surrounded by a white efflorescence on the leaf. The life-history is in general a fairly quick one and there are two or more broods in the rains; so far as known, hibernation is passed in the imago stage. The larvæ are the hosts of parasites, both Tachinidæ and parasitic Hymenoptera having been reared from them. None are serious pests, though more than one lives upon rice and some on palms, turmeric and ginger.

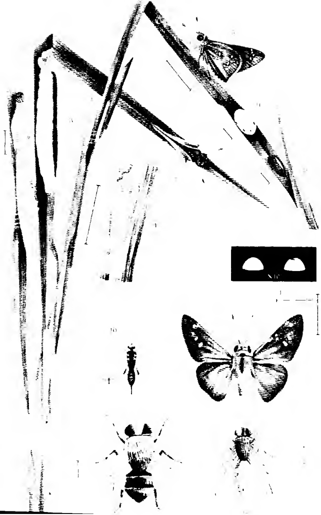
The family is a large one and Mabille has recently enumerated 2,600 species (Genera Insectorum); 190 of these are Indian, a small proportion being plains species. The student should consult Elwes' Revision of Oriental Hesperiidæ (Trans., Zool. Soc., 1896, XIV, p. 101) where many species are figured in colour as well as Watson's "Hesperia Indica" (1891) and de Nicéville's papers. The family is divided into the following sub-families :—

Pyrhopyginæ, Hesperiinæ, Ismeninæ, Pamphilinæ, Megathyminæ.

PLATE XXXIII.—PARNARA

THE RICE SKIPPER.

Fig. 1. Eggs, from the side.
„ 2. Young larva webbing up leaves.
„ 3. Full-grown larva.
„ 4. Pupa in rolled leaf.
„ 5.
„ 6. } Imago.
„ 7.
„ 8. } Puparia of Tachinid parasites.
„ 9.
„ 10. Ichneumon parasite.
„ 11. } Tachinid parasites.
„ 12.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Ismeninæ.—The life-history of *Badamia exclamationis*, Fabr., is told by Dudgeon (Jo. Bo. Nat. H. Soc., X, 1895, p. 184) and his account is quoted by Sharp. The caterpillar feeds on Canna.

Pamphilinæ A.—*Suastus gremius* is superficially like *Parnara mathias*, but has black spots on the hindwing beneath. It is recorded as feeding on rice, but probably is a palm leaf feeder principally. Davidson and Aitken rearing it only from several palms. It is stated to be the commonest skipper in Lucknow (Phillipe). De Nicéville gave an account of it in Indian Museum Notes (I, p. 9).

Gangara thyrsis, Mo. (fig. 295), is a larger species whose larva also feeds on palms. Aitken speaks of the butterfly as coming out before dawn and after dusk. *Matapa aria*, Mo., was found commonly in Calcutta, feeding on bamboo leaves by de Nicéville (Ind. Mus. Notes, Vol. V, p. 115).

Pamphilinæ B.—*Parnara* (*Chapra*) *mathias*, Fabr. (Plate XXXIII), is perhaps the most abundant of the family in the plains, a small olive brown species with whitish speckles on each side of the wings. It is commonly found on rice as a larva or pupa and is occasionally destructive. There appear to be two broods on rice during the rains as a rule: *P. colaca*, Mo., is stated to have fed in paddy in Savan (I. M. N., III. 3, p. 4.)

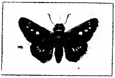

Fig. 296—PARNARA COLACA. (I. M. N.)

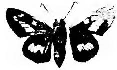

Fig. 298—PADRAONA PALMARUM, FEMALE. (I. M. N.)

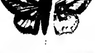

Fig. 297—PADRAONA PALMARUM, MALE. (I. M. N.)

Telicota (***Padraona***) *palmarum*, Mo., is recorded from Date palm and is widespread in India. *T. augias*, Linn., is one of the very common plains species, coloured, like the above, in orange and olive-black; its larva is found breeding commonly on sugarcane, also on bamboos and rice rarely.

Udaspes folus, Cram., is a small black and white species whose larva feeds on turmeric and ginger. It is rarely abundant or injurious, but is widespread over the plains.

HETEROCERA.—*Moths.*

While there is no distinct gap between the *Rhopalocera* and *Heterocera*, there is justification from the practical point of view in separating the two Divisions; the latter have antennæ not knobbed, do not as a rule fly by day, and pupate commonly in a cocoon or in concealment. This great group is a very large assemblage of species and both logically and practically requires breaking up to form workable series. A number of families were formerly separated as *Microlepidoptera*, or Small Moths, but the limits of this series was ill defined. We have preferred to divide them into three series as follows:—

I. *Heterocera*. Thirty-one families, the typical Moths. (see page 399.)

II. *Microlepidoptera*. Ten families, the smaller moths:

Hindwing, vein 8 free, 1c absent.	*Callidulidæ.* *Drepanidæ* *Thyrididæ.*
Hindwing vein 8 connected to cell by a bar or free, 1c present	*Zygænidæ.* *Tortricidæ* *Tineidæ.*
Hindwing vein 8 aborted, 1c present.	*Sesiidæ.*
Hindwing vein 8 anastomosing with or closely approximated to 7. 1c present.	*Pyralidæ.*
Wings divided into plumes.	*Pterophoridæ.* *Orneodidæ.*

III. *Protolepidoptera.*

Cell of hindwing emitting more than 6 veins.	*Hepialidæ.* *Micropterygidæ.*

On this division, we get in one series (*Microlepidoptera*) the families placed by Hampson (as above) at the foot of the order, but also families in which (1) the egg is flattened, not upright, spherical or sculptured and (2) the larva is "Pyrali-form," the suckerfeet in a circle

PLATE XXXIV.—Syntomids and Noctuids.

Fig. 1. Syntomis cyssea, larva.
,, 2. ,, ,, pupa.
,, 3. ,, ,, male.
,, 4. ,, ,, female.
,, 5. Aegocera venulia (Agaristidæ).
,, 6. Euchromia polymena (Syntomidæ).
,, 7. Ceryx godarti. ,,
,, 8. Psychotoe duvaucelii. ,,
,, 9. Syntomis sperbius. ,,
,, 10. Agrotis c-nigrum, larva (Noctuidæ).
,, 11. ,, ,, ,,
,, 12. Polytela gloriosæ ,,
,, 13. Homoptera umbrina ,,

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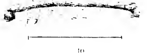

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and not in two opposed lines. From the working point of view the Microlepidoptera becomes a useful assemblage of fairly distinct insects.

We discuss first the typical *Heterocera*, following the order of Hampson's Catalogue of Lepidoptera and enumerating at the head of each family the characters given by him as regards venation. The student will find descriptions, etc., in the Fauna of India and in the author's subsequent papers, still being issued, in the *Journal of the Bombay Natural History Society*.

SYNTOMIDÆ.

Hindwing with vein 8 absent or short, 1c. absent. Forewing with vein 5 nearer 4 than 6.

These moths have, as a rule, a peculiar facies, the wings have hyaline patches, the hind wing is often reduced in size. They are small or of moderate size, the colouring is bright and the plains species are day-flying. The student will confuse them with *Zygænidæ*, from which they are distinguishable only on the venation.

The life-histories of some Indian species are known; eggs are round, yellow, laid in masses together on the foodplant or soil; the larvæ are clothed in tufts of hair, dull-coloured and inconspicuous as a rule (Plate XXXIV). They make a cocoon of silk and hair on the soil. The moths are commonly found sitting exposed on grass stems and plants by day, the conspicuous colouring being apparently warning. Until more is known, it is impossible to discuss hibernation; it is noticeable that *Syntomis sperbius* and *S. cyssea* are, in the plains, common in the cold weather both as moths and as larvæ; larvæ have been reared on rabi (winter) crops, as well as on kharif (rainy season) crops; it is uncertain whether we have some species which breed only in the cold weather and some only in the rains, or whether some breed all the year. Development is not rapid and there are probably few broods a year. None are known to be pests, though some feed upon cultivated plants. Hampson enumerates 1,100 species in the Catalogue of Lepidoptera Phalænæ of which about 100 are "Indian" and perhaps ten found in the plains.

Psychotæ duvauceli, Boisd. (Plate XXXIV, fig. 8), is a small dusky moth, with smoky wings and the abdomen with two orange bands, dilated towards the apex. It is common in the plains though rarely noticed.

Ceryx, in which vein 3 of hind wing is absent, is commonly represented by two species, *godarti*, Boisd. (Plate XXXIV, fig. 7), with two abdominal yellow bands, the hind wing with a narrow black border, and *imaon*, Cram., with a broader black border to the hind wing.

Syntomis, in which vein 3 of the hind wing is present, is similar in appearance. *S. passalis*, Fabr., has seven narrow cupreous bands on the abdomen. *S. cyssea*, Cram.. and *S. sperbius*, Fabr., have each two orange bands on the abdomen, the former having a yellow collar, the latter a yellow metathoracic patch between the wings. *S. cyssea*, Cram., and *S. sperbius*, Fabr., have been reared from red brown larvæ (Plate XXXIV, figs. 1-4 and 9) with dense short tufts of hair found feeding upon sweet-potato, wild *Convolvulaceæ* and oats. They appear to be the most abundant species in the plains.

S. passalis, Sulz.. is less common but its larva may be found upon bean leaves; the life-history occupies two months and broods succeed each other throughout the year.

Euchromia polymena, Linn. (Plate XXXIV, fig. 6), has broad orange spots on the wings, two or more crimson bands on the abdomen, and touches of metallic blue on the thorax and base of each wing. It has a reddish larva, with longer tufts of hair at each end, which feeds upon wild *Convolvulaceæ*.

ARCTIIDÆ.

Hindwing with vein 8 anastomosing with the cell to near or beyond the middle: then remote from 7; frenulum present. Forewing with vein 5 nearer 4 than 6. Hindwing with vein 1c absent.

In this family we have principally small to moderate sized moths, often of bright colouring. The precise object of the bright colouring is not clear since the majority are nocturnal in habit, but as white is often the ground colour, making the moths conspicuous in the dusk, it may be a form of warning colouring.

The antennæ are usually ciliated or bipectinated, the head small and inconspicuous; the proboscis is well developed, the palpi commonly short and porrect. The body is robust and hairy or well scaled; wings are present in both sexes; males and females are alike in colouring and appearance, the former often distinguishable by the pectination of the antennæ. The round sculptured eggs are commonly laid in clusters upon the foodplant and the moths are often very prolific. Larvæ are commonly hairy, with tufts of long hair or a dense uniform clothing. (Plate XXXV.) Five pairs of prolegs are present in all but one division (*Nolinæ*) in which the first pair is aborted. All the known larvæ are herbivorous and the majority feed openly upon plants. Pupation takes place on the soil in a cocoon of silk and hair. Moths are commonly crepuscular or nocturnal and come to light in many cases. So far as has been ascertained, hibernation is passed as a pupa in the cocoon in a sheltered place on or in the soil, the majority of the moths not emerging until the first heavy fall of rain. There are exceptions to this rule, some moths emerging in the dry hot weather and breeding then if food is available. The number of broods varies from one or two to as many as eight. Several are injurious owing to their very **great multiplication** under favourable circumstances and to their

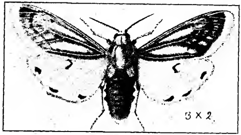


Fig. 299—AMSACTA ALBISTRIGA × 2 (I. M. N.).

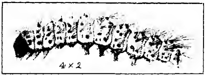


Fig. 300—AMSACTA ALBISTRIGA LARVA × 2 (I. M. N.).

omnivorous habits; they are the common "hairy caterpillars" which are well-known pests in the plains, especially during the early weeks of the rains. The larvæ are very extensively parasitised by parasitic Hymenoptera and Tachinidæ; there is some reason for believing that they are less attacked by birds than the Noctuidæ, for instance, possibly on account of their hairy covering.

Hampson in the Catalogue of Lepidoptera Phalænæ, after separating the *Nycteolinæ* and placing them in the *Noctuidæ*, sub-divides the family as follows: *Nolinæ* without ocelli, with tufts of raised scales in the cell; *Lithosiinæ* without ocelli, without tufts; *Arctiinæ* with ocelli, without tufts. If the later classification be followed, the nomenclature and arrangement of the family as given in the Fauna of India is of no value to the student. The later arrangement is adopted here as it is only a question of time before a revision of the very useful Fauna of India volume will be published.

Nolinæ.—Small moths, with tufts of raised scales in the forewing. Most are hill species, the moths found on trees, the larvæ generally feeding upon lichens and having the first pair of prolegs absent. *Celama internella*, Wlk. (*Nola pascua*, Swinh.), occurs in widely scattered localities in India, the larva feeding on the shoots of the plants of the genus *Rubus*: the cocoon is boat-shaped, of silk and pieces of plant, exposed. The moth is white, the forewing marked and suffused with brown, the hindwing

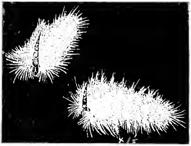
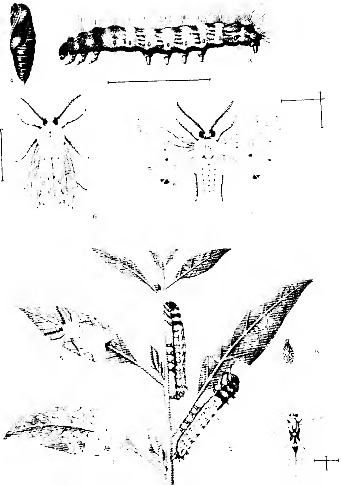


Fig. 301—ROESELIA FOLA : LARVÆ × 1½ (I. M. N.).

PLATE XXXV.—DIACR
BEHAR HAIRY CATE

Fig. 1. Young larva.
,, 2. Full-grown larva.
,, 3. ,, ,, ,,
,, 4. Pupa.
,, 5. }
,, 6. } Imago.
,, 7. }
,, 8. Ichneumon cocoon.
,, 9. ,,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tinged with fuscous in the female, with yellow in the male. *Nola argentalis*, Mo., is found in Sikkim, its larva being stated by Dudgeon to mimic a Coccid which lives on the same leaves. *Rœselia fola*, Swinh., was found by de Nicéville in Calcutta on country almond (*Terminalia catappa*) and he figures it. (I. M. N., V, pl. X). We reproduce his figures. *R. lignifera*, Wlk., also occurs in Mhow (Forsayeth), and Dudgeon describes the larva as making a cocoon of pieces of rotten wood, bark and interlaced long hairs.

Lithosiinæ. Brightly coloured moths, small or moderate in size, flying by day or in the dusk. The larva has few hairs and frequently feeds on lichens, the pupa being in a thin cocoon of hairs. *Ilema vicaria*, Wlk. (*Lithosia antica*, Wlk.), though a hill species, occurs sparingly in the plains, a small moth with narrow wings, lead colour, with a yellow margin.

Chionœma (Cyana) *peregrina*, Wlk., is a white moth with wings banded in scarlet, found in the moister parts of India. *Asura* (Nepita) *conferta*, Wlk., is perhaps the most common of the family after *Utetheisa*. The dark-coloured caterpillar, with tufts of hair and orange spots, is very abundant in the rainy season, on house walls, paths, verandahs, etc.; it feeds on lichens and often appears in great numbers in towns. The moth is orange, the forewings banded with black, the hindwing orange, with a terminal black band. *Asura* (*Miltochrista*) *semifascia*, Wlk., is a small moth, pale yellow in colour, the forewing lined and spotted with black. The larva feeds on mosses; it is clothed in black hair, "which opens out at the joints when it rolls itself into a ball." (Hampson.)

Arctiinæ. Brightly coloured moths, of moderate size and with stout bodies: the larvæ have five pairs of prolegs and are clothed in long hair: the pupa is in a cocoon formed of silk and hair. Most are hill species, a considerable number widespread through the plains.

Diacrisia is a large genus with many Indian species. *D. obliqua*, Wlk. (*Spilosoma todara*, *dalbergiæ*, *bifascia*), is common in and near the hills and in forest localities: it is the predominant hairy caterpillar of Behar and occurs, for instance, also at Poona: the larva is hairy, the ground colour black and yellow, the long hairs black or black and white. (Plate XXXV.) It has as many as eight broods in a year, a single generation taking from five weeks in the rains to 2½ months in the cold weather, though the latter is exceptional. They are found in vast numbers at some seasons and are almost omnivorous so far as crops and low herbage is concerned. There are several varieties of the moth, the var. *confusa* which is suffused with red being a common one.

Amsacta lineola, Fabr. (*Creatonotus emittens*), *A. lactinea*, Cr., and *A. Moorei*, Butl., are found in the plains, being destructive to a variety of crops. Their larvæ are densely clothed in dark hair and appear in swarms in the rainy season. The moths may be distinguished by their colouring. *Amsacta albistriga*, Wlk. (figs. 299, 300), is recorded from South India, where it feeds upon groundnut. (Indian Mus. Notes, V, p. 50.) *Creatonotus gangis*, Linn. (*interruptus*), is also common, the larva hairy with a yellow stripe, the moth pinkish with a broad black fascia on the forewing. *Estigmene perrottetii*, Guer. (Alphæa biguttata), is a beautiful moth, the forewing black with a longitudinal white fascia, the hindwing red with black blotches, found widely over the moister parts of India. With it is *E. vittata*, Mo., found principally in the Mysore and Nilgiri plateau.

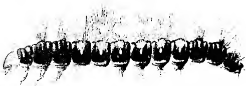


Fig. 302—AMSACTA LACTINEA LARVA, FULL GROWN × 2.

Pericallia ricini, Fabr., is a striking insect, the forewing grey-brown, with series of dark spots with light edges, the hindwing scarlet with black bands. The hairy caterpillar is a pest to castor and *Cucurbitaceæ*, and is general over India. *Utetheisa pulchella*, Linn., is a common species in the plains, the moth flitting about herbage in the day. It is widely scattered over the old world. The brightly coloured

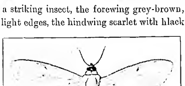


Fig. 303—AMSACTA LACTINEA (I. M. N.).

caterpillar feeds upon Sann Hemp and wild Crotalaria. (Agric. Journ. India, Vol. I.) *Rhodogastria astreas*, Dr., occurs widely spread through the hills and plains. The larva is green with few hairs and series of black spots; the moth is noticeable by the hyaline wings clouded with fuscous at the margins.

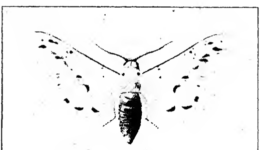


Fig. 304—AMSACTA MOOREI × 2.

Collecting.—In this group what is most required is careful study of larvæ, their food habits and their times of occurrence. There is a great deal to be learnt about this family, which is an important one, and every opportunity of rearing new larvæ should be seized. The foodplants are varied and require careful observation. The number of broods is a very important point as this is a family which apparently reacts very markedly to climatic influences; a great mass of information is required before we can be in a position to generalise on this point, and much interesting work has to be done. Each species must be studied distinctly and in detail and every capture and date will ultimately be valuable.

AGARISTIDÆ.

Antennæ dilated towards the apex: Hindwing with vein 8 anastomosing with the cell at base, then remote, vein 1c. absent. Forewing with vein 5 nearer 4 than 6.

A small and unimportant family of moths, mostly of moderate size, found flying by day. They are, as a rule, brightly coloured and resemble

Noctuidæ. The larvæ are clothed with long scattered hairs and have lateral tufts; the pupæ are naked, without cocoon. None are of any economic importance. Hampson enumerates six genera and 34 species as Indian, of which 5 are not confined to the hills.

Exsula (Eusemia) *victrix*, Westw., occurs in North-West India and Burma. It is a large moth, the forewing black, spotted with blue and yellow, the hindwing blue and black. *Eusemia adulatrix*, Koll., is common throughout the hills of India. The black forewing is banded with yellow and has blue spots at the base; the hindwing is black with red or orange spots. The genus *Zalissa* is by Hampson placed in the Noctuidæ in the new volume. *Aegocera venulia*, Cram. (Plate XXXIV, fig. 5), and *A. bimacula*, Wlk., are the common plains species; the palpi are clothed with long hair, the antennæ dilated, the forewing is red-brown with a light median streak.

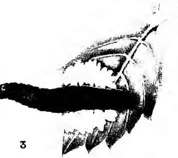
NOCTUIDÆ.

Antennæ not dilated, hindwing with vein 8 *anastomosing with the cell at base then diverging,* 1c. *absent. Frenulum present. Forewing with* 5 *from nearer* 4 *than* 6. *Moths with short robust bodies; moderate antennæ, which are pectinate in the males of a few, usually simple or ciliate. The forewing is stiff and narrow, the hindwing larger. Colours usually sombre.*

This very large family includes moths varying from one-quarter of an inch to five inches in expanse, the majority of about two inches. Some of the very largest moths are included in this family as well as some of the smaller. The colours are mainly cryptic and sombre combined often with deceptive colouring, often so assimilating the insect to its surroundings that it habitually spends the day sitting motionless on a tree-trunk or stone, securely protected by its invisibility. There is a general similarity of facies about the majority, which helps in placing them, whilst some have the form associated with other families. The antennæ are moderately long, usually simple or ciliated, sometimes pectinate. The labial palpi are prominent and are of value in the classification, being porrect or upturned, in some very large and conspicuous. The proboscis is usually present. The thorax is robust and densely scaled or hairy, the abdomen short, thick and evenly tapering, clothed in hair and

PLATE XXXVI.—Noctuidæ.

Fig. 1. Zalissa venosa. Larva full-grown.
„ 2. „ „ Larva, 2nd and 3rd abdominal segments.
„ 3. „ „ „ with cocoons of braconid parasitic larvæ that have emerged from it and pupated.
„ 4. Zalissa venosa. Pupa.
„ 5. „ „ Hind end of pupa.
„ 6. „ „ Moth.
„ 7. Cosmophila erosa. Female.
„ 8. „ „ Male.
„ 9. Eublemma cretacea.



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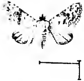

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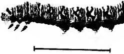

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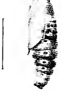

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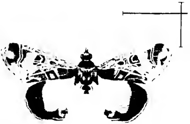

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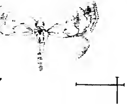

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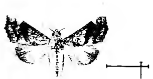

often tufted. The legs are of moderate size, the tibiæ often with spurs and spines. Males are distinguished by many minor characters such as the pectination or ciliation of the antennæ, the presence of scent diffusing hair-tufts on wings or legs and rarely by the different colouring; females are usually the larger.

The life-history in all is uniform in general characters. The eggs are round and the micropyle is at the top; most are a pearly white or dull green, beautifully ribbed and sculptured; they are laid singly or in clusters on the foodplant, the clusters sometimes covered with hair. The larvæ have three to five pairs of prolegs, the first two pairs being reduced in some sub-families when the motion approaches that of the true looping caterpillars; these larvæ are known as semi-loopers and it is worth note that the first two pairs of prolegs are proportionately less developed in the young than in the old larva. The hooks on the prolegs are arranged in two opposed lines and not in a circle. As a rule, the larvæ are not clothed in hair, nor do they have long processes. The typical larva is smooth with regularly disposed short hairs and a dull brown or green colouring. (Plate XXVIII, figs. 2, 5.) With very few exceptions they are herbivorous, a few boring in plants, the majority living on leaves. *Eublemma* is the sole genus known to include larvæ which habitually feed on mealy bugs, but many leaf-eating larvæ are cannibals if confined with insufficient food.

Pupation takes place in the soil with no cocoon, but a case of consolidated earth, on the surface with a cocoon and leaves. or, more rarely, on plants in a cocoon. The imago is nocturnal, emerging at dusk. Hibernation, when it occurs, takes place normally in the resting larva or pupa stage, a few living through the winter in hiding as imagines. Some are active through the winter, especially in the moister parts of India, but the majority have food only in the rains. A number emerge as imagines in March and live until the rains if their foodplant is not available. Little is known as to the food of the imago, but it is certain that some feed on nectar, on fruit juice and on the sap exuding from plants. Some (*e.g.*, *Ophideres*) are habitual feeders on the juice of fruits, piercing the rind with their proboscis to obtain the juice. In some reproduction is very rapid and the number of eggs laid totals hundreds and in some cases thousands. The smaller forms destructive to crops have several broods yearly, the larger forms and wild forms only one or two.

A considerable number have a large number of foodplants, including cultivated plants, and these often become injuriously abundant. The pests fall into several series, as pests, including the seed-eating species, the surface caterpillars, the swarming caterpillars and leaf-eating caterpillars. None are household or grain pests. These insects have many enemies, notably the parasitic Hymenoptera and Diptera. These parasites can very commonly be reared from the larvæ or pupæ and constitute a very important check without which the crop feeding species would be far more frequently injurious. Predaceous insects (*e.g.*, *Carabidæ*) also attack the larvæ, and the fossorial Hymenoptera carry them off to store for their young. Birds, especially Mynas, attack the larvæ, and the moths are probably destroyed by birds and bats.

The family is a very large one, Hampson listing more than 2,000 Indian forms, the majority of which are from the hills. The number of species actually generally distributed outside the hill and forest areas is probably within 300, but these have not been as carefully collected. About fifty are known as crop pests or feeders on cultivated plants and this number will probably be increased.

Hampson in the Fauna of India divides them into nine sub-families. In his more recent Catalogue of Lepidoptera Phalænæ, wherein he lists the species of the world, the classification is revised and fifteen sub-families are recognised. While this is probably a more natural classification, it is as yet incomplete, and as the nomenclature formerly used differs markedly from that now being published, the revised nomenclature is used, when possible, with the old in a bracket, thus admitting of reference to the volumes on the Fauna of India; the sub-families adopted are those of the Catalogue, and we have followed Dudgeon* in placing the genera in their sub-families.

KEY TO THE SUB-FAMILIES.

A. Maxillary palpi absent.

B. Hindwing with vein 5 obsolescent from or from just below middle of discocellulars.

C. Mid and hind tibiæ, or hind tibiæ only spined .. .. .. *Agrotinæ*.

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* We have to thank Dr. Annandale for permission to use the Dudgeon collection arrangement.

C.C. Mid and hind tibiæ not spined.
D. Eyes hairy .. .. *Hadeninæ.*
D.D. Eyes not hairy.
Eyes with long overhanging cilia .. *Cucullianæ.*
Eyes not ciliated .. .. .. *Acronyctinæ.*
B.B. Hindwing with vein 5 well developed.
C. Hindwing with vein 5 more or less approximated to 4 at base.
D. Frenulum of female simple.
Abdomen with lateral anal pencils of hair .. *Euteliana.*
Abdomen without anal pencils of hair; forewing with tufts of raised scales in cell .. *Stictopterinæ.*
D.D. Frenulum of female multiple.
E. Retinaculum of male bar-shaped.
Forewing with tufts of raised scales in cell *Sarrothripinæ.*
Forewing without tufts of raised scales in cell *Acontianæ.*
E.E. Retinaculum of male not bar-shaped.
F. Mid tibiæ spined .. .. .. *Catocalinæ.*
F.F. Mid tibiæ not spined.
G. Eyes hairy .. .. *Mominæ.*
G.G. Eyes not hairy.
H. Eyes with long overhanging cilia .. *Plusianæ.*
H.H. Eyes not ciliated.
Hindwing with vein 5 from close to lower angle of cell, strong .. .. .. *Noctuinæ.*
Hindwing vein 5 from well above angle of cell, rather weak .. .. .. *Erastrianæ.*
C.C. Hindwing with vein 5 parallel to 4 .. *Hypeninæ.*
A.A. Maxillary palpi present .. .. *Hyblæinæ.*

As the further classification is based on venation, necessitating the preparation of wings, and requiring more study than is desirable, the venation has been disregarded and reference to it omitted. For accurate identification, the venation must be made out and it is not the purpose of this volume to enable species to be identified. The student of the family will find this in the two works mentioned above and, unless the family is to be very closely studied, it is advisable not to attempt to identify a species solely from the data available in those volumes, and without a reference collection. With so large a group much must be omitted, and we have selected for mention those species only which are likely to be found as crop pests, which are found feeding on common plants or which are striking and likely to be noticed.

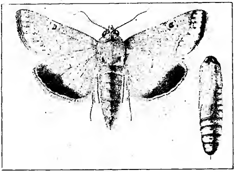


Fig. 305 -CHLORIDEA OBSOLETA PUPA AND MOTH × 2.

Agrotinæ.—Hampson lists 1,200 species, of which about a tenth are Indian in the very broadest sense, *i.e.*, reach some part of the Himalayan region of British India. A very small number get beyond the Himalayas Southwards into India proper, these occurring principally in hill localities such as the Nilgiris and Western Ghauts. The proportion of palæarctic species ranging completely across Northern Europe and Asia is very striking and a number of these extend into the Himalayas and rarely into submontane districts of India.

Chloridea (Heliothis) includes three species common in the plains. *C. obsoleta*, F. (armigera), is olive-grey or reddish brown, with the postmedial line indistinct and dentate. *C. assulta*, Guen., is orange to orange-brown, with a strongly marked postmedial line that is hardly dentate; *C. peltigera*, Sch., is ochreous to orange, with a black sub-terminal point above the tornus. The first is the universal pest known as the American bollworm. It is an omnivorous insect, whose life-history is elsewhere described in detail. The second is a less abundant species, feeding on tobacco and tipari in the plains. The third is European and recorded from scattered localities in India.

Adisura (Chariclea) *marginalis*, Wlk., is a pretty pink and yellow moth common in the plains. *A. atkinsoni*, Mo., is also common, but has apparently not been reared. The genus *Agrotis* as it stands in the Fauna of India is now divided on structural characters, the majority falling into *Agrotis* and *Euxoa*. The former includes *A. ypsilon*, Rott., the "Universal Greasy Cutworm" and the very common *A. flammatra*, Fabr. Both species have a curious habit of hiding in sheltered spots in houses in the cold weather, and the latter especially is found in thatched roofs. In March the moths emerge, and when my office was in a thatched barn, living *flammatra* moths used to fall out of the thatch, tightly wrapped in a clothing of spiders' web; apparently the moths hibernated there, were spun up by spiders, woke up in March and in struggling to escape fell out of the thatch. *Agrotis c-nigrum*, Linn., and *A. descripta*, Brem., also breed in the plains but rarely. (Plate XXXIV, figs. 10, 11.)

Euxoa includes *E. segetis*, Sch. (*suffusa*), *E. corticea*, Schiff., and *E. spinifera*, Roth. (*biconica*), with other less common species. The larvæ of these behave as Surface Caterpillars, just as the larva of *A. ypsilon* Rott., does: all are figured in the Agricultural Journal. Vol. II, p. 42, and in Memoirs of the Agric. Dept., Entom., Vol. I, No. 2.

Hadeninæ.—Hampson lists 946 species in the world of which over 120 are "Indian." Nearly all of these are species occurring in Central and Northern Asia, which extend into the Himalayas and rarely into the Khasis. A few are peculiar to India and Ceylon, while a few range over the Indo-Malayan or Indian and Indo-Chinese area. *Glottula dominica*, Cram., is a dull brown moth, the forewing with a series of sub-marginal lunules, the hindwing white. The larva bores into the fleshy leaves of lilies and is black, thickset and warty, spotted with white, the head, legs and two ends of the body marked with red. It is a conspicuous insect with apparently warning colouring. *Polytela gloriosæ*, F., has a somewhat similar larva, but smooth, and slightly differently marked. It feeds upon the leaves of Amaryllids and the moth is blue-black, with orange specks, the hindwing alone fuscous, with orange cilia. It is a pretty and striking insect with more beauty than most of its family. (Plate XXXIV, fig. 12.)

Cirphis (Leucania) includes two very common species known as pests in the plains. *C. unipuncta*, Haw., is the destructive "Army worm" of world-wide distribution, whose larvæ feed upon rice, maize, juar and other crops, occurring often in very great abundance. There is a voluminous literature regarding this insect, one of the best accounts being Tryon's (Queensland Agric. Journ., 1900, p. 135). He states that the moth lays 500 to 700 eggs, there being two broods yearly in Australia ; abundant enemies and parasites check its excessive multiplication normally. The larva may be known by the plate over the base of each suckerfoot, a character not found in other Indian injurious Noctuids. *C. loreyi*, Dup., is also found upon cereals, but the larva occurs also underground, feeding upon the roots of plants or coming out at night to feed. *C. fragilis*, Butl., is reported as having been destructive to wheat in Chindwara, but has not been found since that time as a pest.

Borolia is most commonly represented by B. *venalba*, Mo., whose larva feeds upon rice leaves.

Polia (Hadena) is a large genus of moths superficially like *Agrotis*, but with hairy eyes and tufts on the abdomen. *P. consanguis*, Guen.,

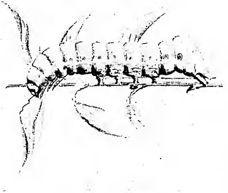


Fig. 306—EUSCOTIA SP. LARVA ON OCIMUM × 2

with several varieties, is common and has been reared from pupæ found at the roots of trees.

Cuculiinæ—Hampson lists 50 out of 590 species as Himalayan, Khasi Hills or Kashmir. One only extends further South, *Euscotia inextricata*, Mo., being found in the Nilgiris and Himalayas. We have one other and apparently undescribed species or variety reared at Pusa on *Ocimum canum*.

Acronyctinæ. Euplexia conducta, Wlk., feeds on Niger seed, Jute, Safflower and on *Coreopsis*. It is not uncommon on the former plant. The smoky form *dolorosa* feeds on Kakaronda (*Blumea balsamifera*). *E. melanospila*, Koll., is a moth of varied markings with dark green and dark brown ground colour, common in the plains. *E. indistans*, Guen., has been reared from larvæ found in the soft bark of the Gular tree (*Ficus glomerata*), whither they had retired to pupate. Others were found under the bark of teak.

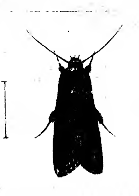


Fig. 307—MUDARIA CORNIFRONS.

Mudaria cornifrons, Mo., is a grey moth with fuscous markings distinguished by the possession of a three-pointed chitinous process on the frons. Its larva is commonly found feeding in the pods of silk cotton (*Bombax malabaricum*). It " hibernates " as a pupa from May or June to the following March, in the soil; this has been conclusively proved by actual breeding in the Pusa insectary. *Prodenia littoralis*, Boisd., is widely distributed and commonly destructive: its foodplants include a great number of wild and cultivated plants. (Mem. Dept. Agric., Ent., Vol. 1, No. 2.) The larva, up to the last instar, may be known by the transverse raised black band across the first abdominal segment above. A full account is given in Mem. Agric. Dept. Ind., Ent., Vol. II, No. 6.

Spodoptera mauritia, Boisd., is a grey and black moth with a blotch of white on the forewing, distinguished by the immense tufts of hair on the forelegs of the male. The larva feeds on rice, grasses and millets appearing sometimes in great abundance in the rains and soon after. It is often obtainable on dubh grass (*Cynodon dactylon*) lawns, with other noctuid larvæ. *Berresa turpis*, Wlk., is a smaller dark-coloured moth, most easily recognised by the vesicle in the cell of the male forewing, covered by a tuft of scales below; it is common at the close of the rains. *Amyna selenampha*, Guen., and *A. octo*, Guen., are deep brown, with slender upturned palpi and tapering abdomen, found under trees. The larva of the latter has been reared on sweet potato, a green larva with two black crescents on the thorax above. The former is recorded by Green as a serious pest to the Croton Oil plant in Ceylon.

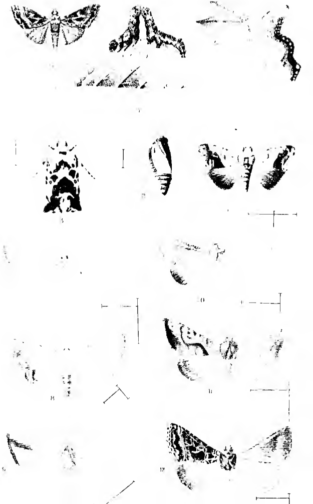
Callopistria recurvata, Mo., is the only common species of the number found in India; the male has curiously curved antennæ with three spatulate hairs at the curve, the legs also densely clothed with long hair.

Caradrina is a genus of many species, of which one is abundant and destructive. This is the cosmopolitan *C. exigua*, Hubn., a very widely distributed species, destructive to a number of crops but particularly to indigo in its young stage. (*See* Agric. Journ., India, Vol. I, pt. IV, for a full account.) This moth is like a small *Euxoa segetis*, but has no spines on the legs. *Caradrina pecten*, Guen., was reared from larvæ found in the dubh grass on a lawn and is apparently common. The larva is brown and orange with black stripes, the pupa, as usual, in the soil.

Nonagria uniformis, Ddgn. (Plate XXXVII, fig. 7), has been the subject of much inquiry, since it is the important stem-borer of wheat in the cold weather; it then attacks sugar-cane and injures the young shoots and canes; it has been reared in maize, guinea grass and juar, and, finally, it severely attacks rice. The pink caterpillar is a borer, not feeding in the open. The moth is dry-grass colour; the species is not recorded in the Fauna of India, but was described since, and the species *N. inferens* was probably confused with this, since the specimens in the Indian Museum and the Pusa collection, from which it was described, are all stated by Mr. Dudgeon to be his species, *N. uniformis*.

PLATE XXXVII.—NOCTUIDÆ.

Fig. 1. Tarache tropica, larva.
,, 2. ,, ,, pupa.
,, 3 ,, ,, moth.
,, 4. ,, ,, ,,
,, 5. ,, notabilis, larva.
,, 6 Plusia daubei.
,, 7. Nonagria uniformis.
,, 8. Eublemma amabilis.
,, 9. Acontia intersepta.
,, 10 Plusia orichalcea.
,, 11. ,, agramma.
,, 12. ,, jessica.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Euteliinæ.—A single genus, *Eutelia*, is common in our limits with four species, *E. delatrix*, Guen.; *E. jocosatrix*, Guen.; *E. nugatrix*, Guen.; *E. favillatrix*, Wlk.

Stictopterinæ.—*Risoba obstructa*, Mo., feeds on *Quisqualis indica* and is common in the plains. *Odontodes aleuca*, Guen., is a deep brown moth, with black stipples and a crenulate margin to the forewing, found generally in the plains.

Sarrothripinæ.—The wings are commonly narrowed at the base, of even width otherwise, with patches of raised scales on them. The palpi are porrect or upturned. *Plotheia celtis*, Mo., is a small grey brown moth with a spiral dark line on the forewing. Its larva feeds on the leaves of litchi (*Nephelium litchi*) and gular (*Ficus glomerata*): it is rather sparsely clothed with long grey hairs which project over the head and tail and from the sides; a rough silken cocoon is formed on the soil covered with excrement: the life-history is rapid, less than one month in June. De Niceville records it also (Ind. Mus. Notes, V, p. 108) as feeding on the leaves of *Terminalia catappa*, the country almond, and *Gmelina arborea*. Another species, *P. nephelotis*, Meyr., has been found feeding on the leaf of Brinjal (*Solanum melongena*) and this appears to be a common plains species. The larva is short and thickset, dark coloured with brilliant yellow spots and long hairs. It turns the edge of the leaf over and lives within.

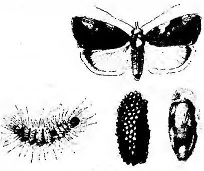


Fig. 308.—PLOTHEIA CELTIS LARVA, COCOON AND PELLETS, COCOON, IMAGO. (I. M. N.)

Chlumetia transversa, Wlk., is worth mention as de Nicéville records it (Ind Mus. Notes, V, p. 125) as boring in the shoots of mango at Dehra Dun. It is found in this habitat also in Bombay and has once been reared on litchi leaves with a batch of *Plotheia celtis*. *Cletthara sceptica*, Swinh., is a small grey-black speckled moth, whose green semi-looping larva was reared from velvet beans. It appears to be rare.

Acontiinæ.—*Acontia* includes larger moths of a yellow colour (Plate XXXVII, fig. 9) whose larvæ are found on cotton, bhindi (*Hibiscus esculentus*) and other *Malvaceæ*. The larvæ are green with white spots and short hairs, having three pairs of prolegs. Four species are mentioned, all occurring commonly, *A. malvæ*, Esp., *A. transversa*, Guen., *A. intersepta*, Guen., and *A. grællsii*, Feisth., though we doubt their real distinctiveness. The larva of *Carea subtilis*, Wlk., has been reared on the Jamun tree (*Eugenia jambolana*); it has a curious voluntary dilatation of the first thoracic segment, which gives it a quaint appearance. It pupates under the bark in a cocoon of beautiful white silk.

Callyna jugaria, Wlk., is a beautiful moth, the forewing deep purple with greyish lines and an apical light spot, found throughout India, though rarely.

Catocalinæ—*Anisoneura hypocyanea*, Guen., is the large deep brown moth with many dark markings which emerges in June and is found on the bark of trees in the rains and flying in the dusk. It has an expanse of 3½ to 5 inches, and is most beautifully coloured in deep brown and black to harmonize with the bark when both wings are spread fully out.

Nyctipao includes large deep-coloured moths up to five inches in expanse, with posterior tibiæ spined; the large ocellus-like markings on the forewing are very striking. Four species are found, *N. macrops*, Linn., *N. hieroglyphica*, Dr., *N. caprimulgus*, F., and *N. crepuscularis*, Linn. The male of the first is characterised by an immense tuft of buff flocculent hair in a costal fold of the hindwing.

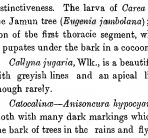


Fig. 309—REMIGIA ARCHESIA.

Remigia includes two moths of moderate size, brown with variegated lines. *R. archesia*, Cram., is deep brown, its larva is yellow-green with broad black stripes and attains a length of two inches; the foodplants include such cultivated leguminosæ as Urid (*Phaseolus mungo*) and indigo. It is one of the many caterpillars found upon indigo in the rains and is sometimes extremely abundant. *R. frugalis*, Fabr., is greyer and less distinctly marked: the brown larva lives on rice, juar and other Gramineæ, pupating in a cocoon surrounded by leaves. It is a common insect, not known to be often injurious. *Trigonodes hyppasia*, Cram., is readily recognised from the very distinct markings; the yellow semi-looping larva feeds on indigo and other leguminosæ, with *Remigia archesia*. The moths are often extremely abundant in long grass and are found at almost all times. *T. cephise*, Cram., though recorded only from Burmah, is found in India.

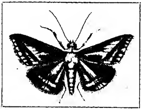


Fig. 310—REMIGIA FRUGALIS.

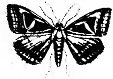


Fig. 311—TRIGONODES HYPPASIA

Grammodes geometrica, F., is closely allied, the markings distinct and recognisable, found also in grass; the larva feeds on rice. *G. stolida*, F., a smaller moth is also found, though more rarely. *Spirama retorta*, Cram., and *S. vespertilio*, Fabr., are large dark moths with the peculiar "inverted comma" marking on the forewing. In the former the female has the ground colour ochreous, the male having the forewing wholly dark. This insect appears in the hot weather.

Ophiusa is a large genus of moderate-sized moths with upturned palpi, the tibiæ fringed with long hair in the male. The larva is semi-looping, with the first or first two pairs of prolegs obsolescent and with a double process on the hind end of the body. There are several common species, the most abundant being *O. melicerte*, Dr., the common pest of castor which also feeds upon the common weed, dudhi (*Euphorbia pilulifera*. For a full account see Mem. Agric. Dept., Ent., Vol. II, No. 3. *O. algira*, Linn., also feeds on castor but appears to be rarer. Other common species are, *O. serva*, Fabr.; *O. illibata*, Fabr.; *O. palumba*, Guen.; *O. dotata*, Fabr.; *O. mejanesi*, Guen.; *O. arcuata*, Mo.; *O. joviana*, Cram. (feeds on *Phyllanthus*); *O. arctotænia*, Guen.; *O. analis*, Guen.; *O. crameri*, Mo.; *O. onclia*, Guen. (feeds on *Phyllanthus*); *O. coronata*, Fabr. (feeds on *Quisqualis*, and has the hindwing orange); *O. trirhaca*, Cram. (hindwing orange, feeds on guava); *O. honesta*, Hubn. (hindwing crimson); and *O. fulvotænia*, Guen., in which the male has the mid tibia cleft and filled with scales. The larva of *O. coronata*, Fabr., is very striking, a very long grey-brown larva with two tiny oval tubercles, which clings tightly to the shoots, pressed closely against them and so being very difficult to see. The first we found was due to a mynah jumping from the ground and snapping one off a *Quisqualis* bush.

Homoptera is similar, the male with heavy tufts of hair on the fore tibiæ. It includes the two common species, *H. umbrina*, Guen. (Plate XXXIV, fig. 13), and *H. glaucinans*, Guen.; Forsayeth (Trans. Ent. Soc., 1884, p. 379), reared these species and his paper may be consulted.

Mominæ comprises the genus *Moma*, not included here.

Plusiinæ. *Plusia* is a large genus of which several species occur in the plains, some as pests. The discrimination of these species is a matter of difficulty as the markings are closely alike in a large number of species. (Plate XXXVII.) *P. orichalcea*, Fabr., is distinguishable at once by the large brassy patch on the forewing, occupying the centre up to the outer margin. The larva feeds on Cruciferous plants and is common in the cold weather; it is green with a marked lateral white line and conspicuous black spines. *P. agramma*, Guen., is nearly uniformly coloured in grey-brown, the forewing with dull bronzy reflections. The larva feeds on Cucurbitaceous plants. (Plate XXVIII, fig. 13.) The remaining species have the "Y" mark in some form on the forewing and cannot be identified save from a comparison of specimens. *P. limbirena*, Guen., feeds upon indigo in Behar. (Ind. Mus. Notes, V, p. 162.) *P. ni*, Hubn., is not uncommon feeding upon opium, cabbage and safflower. *P. signata*, Fabr., feeds on cabbage and is an occasional pest. *P. chalcytes*, Fabr. (eriosoma, Doubl.), is common, the green larva feeding on mint and on cultivated pulses and Sann hemp. It is said by Hampson to feed on *Ficus*: Grote reared it on Geranium. *P. nigrisigna*, Wlk., feeds on gram, lucerne and peas and is a common pest. *P. daubei*, Boisd, has been found feeding upon mint, the larva dull brown in colour.

Noctuinæ—*Arcte cærulea*, Guen., is a dark moth with blue on the wings, the male with a long fringe of hair on the inner margin of the hindwing. We figure the larva from Hampson. *Sphingomorpha chlorea*, Cram., will be mistaken for a hawk moth, a large moth with long narrow body and forewing. The palpi are upturned, the third joint long and slender; Forsayeth reared the larvæ on an Acacia, and describes them as green, with white marks and a bar of orange and blue which can be concealed. *Polydesma* includes moths of moderate size, found in grass or on the bark of trees. *P. quenavadi*, Guen., has been reared from caterpillars, found in bark. Other common species are *P. umbricola*, Boisd.; *P. spissa*, Guen.; and *P. inangulata*, Guen.

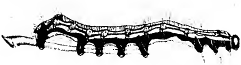


Fig. 312—ARCTE CŒRULEA LARVA.
(*From Hampson.*)

Cosmophila is an important genus with four common species. *C. mesogona*, Wlk., is dark red-brown in colour with very slight markings. *C. sabulifera*, Guen., is distinct with some doubt: its colouring is very varied. The semi-looping larva is found on jute during the rains. (Agric. Journ., Vol. II, p. 109.) *C. fulvida*, Guen., is stated to have a larva with four pairs of suckerfeet that feeds on *Waltheria indica*. It has been found on *Abutilon avicennæ*, a green caterpillar with the first prolegs reduced in size: pupation takes place in a leaf folded over with silk. *C. erosa*, Hubn., is common as a green semi-looping larva on cotton and malvaceous plants; the male moth is darker in colouring than the female. (Plate XXXVI, figs. 7, 8.) The semi-looping larva is a common pest of cotton.

Malachra capitata, bariar (*Sida rhombifolia*) and some other plants during the rains.

Zalissa venosa, Mo., is found breeding upon the common creeper panchanjuria (*Vitis trifolia*); we figure the larva which is not common but may be found in the rains. This species is in the Fauna placed in the *Agaristidæ*. (Plate XXXVI.) *Trisula variegata*, Mo., has an expanse of three to five inches, and is red-brown with dark markings. The larva is stated to be red-brown with numerous blue warts clothed with rather sparse tufts of long hair; it feeds on the pipal (*Ficus religiosa*), and the cocoon is covered with stones, excrement, etc. (Hampson.) *Erygia* has very slender palpi almost naked; *E. apicalis*, Guen., is common, a small moth of dark red-brown colour. *Lacera alope*, Cram.. is dark reddish with grey markings; the larva is known from Ceylon and is green with two anal tubercles. *Hamodes aurantiaca*, Guen., is a moth of an orange brown colour, the forewing produced and with an oblique line from the apex across both wings. At rest it very closely resembles a dead leaf and is found in wooded places.

Ischyja manlia, Cram., is a large dark brown moth. the smaller male with dark blotches on the forewing, both sexes with a conspicuous blue band on the hindwing. It is not uncommon as a moth during the rains. *Spiredonia* is smaller with two common species, *S. anops*, Guen., and *S. feducia*, Stoll. *Hylodes caranea*, Cram., is brown, with a light band across the ends of the wings. The green larva, which has two anal tubercles. is said to feed on Acanthads. *Catephia linteola*, Guen., is larger, the male with heavily tufted fore femora and tibiæ, which are absent in *C. acronyctoides*, Guen. *C. inquieta*, Wlk., was reared from larvæ feeding upon sweet potato in Behar. It is not uncommon in Bengal generally upon this crop; the caterpillar is grey with bright vermilion stippled stripes, a yellow lateral line and, at the hind end, a single round white spot on the dorsal surface. (Plate XXVIII, figs. 4, 5.)

Sympis rufibasis, Guen., is stated to feed on the litchi (*Nephelium litchi*), the pupa found in the rolled end of the leaf (Moore). *Plecoptera reflexa*, Guen., is a small grey moth abundantly found in long grass near sissoo trees (*Dalbergia sissu*). The larva is green, the first two pairs of suckerfeet reduced; it feeds on the leaves of *sissoo*, pupating in the bark or on the soil among fallen leaves. *Acantholipes pansalis*, Wlk., is a small dull brown moth found abundantly in long grass and under trees.

Ophideres is a large genus of large 'yellow underwing' moths, with several species common in the plains. The moth sucks the juice of fruit and at least one species (*O. fullonica*, Linn.) is destructive to orange cultivation on that account. The common species are *O. salaminia*, Fabr.; *O. ancilla*, Fabr.: *O. fullonica*, Linn.; *O. materna*, Linn.; and *O. hypermnestra*, Cram. The student should see Moore's revision of Ophiderinæ (Trans. Zool. Soc., XI, p. 63) where he figures imagines and larvæ. The latter are large dark coloured insects, smooth with large yellow and red eye spots and are humped semi-loopers. In spite of the large size of the caterpillars, they are seldom found; the larvæ of *O. materna* are dark brown, with blue transverse bands, red spots on the thorax and red transverse bands on the second and third abdominal segments. Pupation takes place among dry leaves fastened with silk. The moths are typical examples of the deceptive colouring found in many Noctuids, the forewings being cryptically coloured, the hindwings bright, the moths resting with the latter covered and only exposing them in flight. (Compare with *Anisoneura*.)

Thermesia rubricans, Boisd., varies in colour from light ochreous brown to deep red brown; its larva is green, semi-looping, and feeds upon Urid (*Phaseolus mungo*) and other Leguminosæ, being often abundant in the rains.

Erastriinæ. Hyelopsis signifera, Wlk., is a pretty little white and brown moth, whose green semi-looping larva has been found feeding on rice leaves. The full-grown larva folds the rice leaf over in three folds and makes a cocoon within this, the pupa wriggling half out for the emergence of the moth.

Tarache is an important genus, its larvæ being semi-loopers feeding on weeds and cultivated plants, the moths in all cases sitting exposed on plants and having a more or less close resemblance to bird droppings. Five species are known in the plains. *T. catena*, Sow.; *T. opalinoides*, Guen.; and *T. notabilis*, Wlk., are pure white moths with lead coloured markings on the forewing. The last has a conspicuous larva with six prominent yellow spots, which feeds on cotton and wild Malvaceæ, appearing occasionally in great abundance. *T. opalinoides*, Guen., has been reared from beautiful red semi-looping larvæ found eating the leaves of *Abutilon indicum*; the first two pairs of prolegs are reduced, pupation takes place in the soil and the moth appears in the rains. *T. tropica*, Guen., is yellowish, with olive-green markings at the base of the wing, the apical half with a broad band of deep olive-brown, this being much darker in the female than in the male. (Plate XXXVII.) The larva feeds on bariar (*Sida rhombifolia*); it is green with small yellow and white spots and has three pairs of prolegs. Its attitude on the plant is very striking, the body curved and rigid, the thorax approached to the apex of the abdomen; it clings thus to the margin of the leaf. *Tarache imbuta*, Wlk., is darker yellow, the outer area of the wing deep red-brown. *T. crocata*, Guen., is still darker but may be known by the yellow or orange hindwing; its larva has been reared from jute (*Corchorus*), whose leaves it eats.

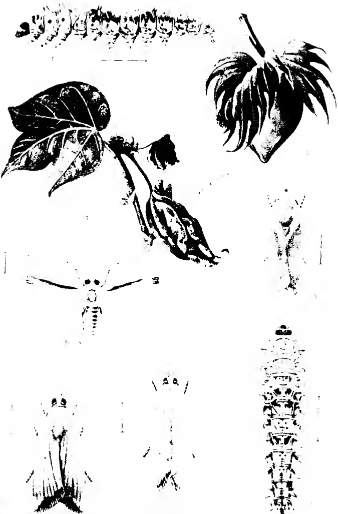
Xanthoptera nigripalpis, Wlk., is a small ochreous moth with the reniform dark and the cilia black spotted, one of the many moths found commonly in thick grass and low vegetation in the plains in September. *Naranga diffusa*, Wlk., is a pretty moth, the male dark purple red, the female yellow with red bands, whose larva feeds on rice leaves; the larva is a semi-looper, green with a lateral yellow stripe; it pupates on the soil without a cocoon.

Earias, included by Hampson in the *Arctiidæ*, is now placed in this sub-family. It includes three common species, feeding on *Malvaceæ*. *E. insulana*, Boisd., has the forewing green, rarely with an ochreous tinge; it feeds on the seeds and shoots of cotton and bhinda (*Hibiscus esculentus*), as does the larva of *Earias fabia*, Stoll., in which the moth is buff, with or without a green wedge down the forewing. Both are fully described as the Spotted Bollworms of India and are pests of the first magnitude. *E. chromataria*, Wlk., has the forewing green with some bright orange and brown suffusion and its larva feeds on cultivated Hibiscus, and has been reared from jute seed-capsules. The habit of the larvæ of boring into shoots and seed pods is unusual and notable for members of this group. (Plate XXXVIII.)

Eublemma includes several common species in which the palpi are upturned and reach the vertex of the head. The genus is remarkable for including species which feed upon plants as well as species which

PLATE XXXVIII.—EARIAS.

Fig. 1. Larva of *E. insulana.*
,, 2. An attacked boll.
,, 3. An attacked shoot of cotton.
,, 4. *E. insulana,*
,, 5. Larva of *E. insulana.*
,, 6. *E. insulana,* yellow variety
,, 7. *E. chromataria*
,, 8. *E. fabia*



feed upon *Coccidæ*. Green in Ceylon found *E. coccidiphaga*, Hmpsn., feeding upon mealy bugs; in India *E. amabilis*, Mo. (Plate XXXVII, fig. 8), feeds upon the lac insect (*Tachardia lacca*) and at least two other species, *E. cretacea*, Hmpsn. (Plate XXXVI, fig. 9), and *E. coccidiphaga*, Hmpsn., feed upon mealy bugs. The commonest species are *E. olivacea*, Wlk., the forewing white with olive-green suffusion, whose larva bores in the green shoots of the briujal (*Solanum melongena*) and wild *Solanaceæ*; *E. rosita*, Guen., ochreous with the outer half of the wing pink; *E. divisa*, Mo., bright yellow with the outer half of the forewing bright pink; *E. hemirhoda*, Wlk., differing from the last in its sub-marginal partial ochreous band, and *E. abrupta*, Wlk., which is red-brown, its larva found upon fig trees. The common species which may be reared upon the cotton mealy bugs (*Dactylopius nipæ*) is an undescribed species. *E. trifasciata*, Mo., has been reared from caterpillars boring into the pods of a species of *Rivea* and *E. parva*, Hubn., from caterpillars feeding on Kakaronda (*Blumea balsamifera*).

Zagira includes two common moths, in which the colour is dark but a broad light band crosses the thorax and occupies the costal half of each forewing. *Z. irrecta*, Wlk., in which the colour is red-brown and *Z. divisa*, Wlk., in which it is nearly black are both to be found in herbage in the plains.

Hypeninæ (*Deltoidinæ*).—These moths are recognisable by the sickle-shaped palpi, curving up to the front of and over the head. *Raparna* includes *R. digramma*, Wlk., *R. ochreipennis*, Mo.; and *R. imparata*, Wlk.; which are more or less common in the plains; de Nicéville records finding *R. nebulosa*, Mo., in abundance on indigo in Chumparan and in fact stated it to be the commonest indigo caterpillar in the rains. As it is recorded only from Sikkim and Bhutan and has not since been found on indigo, this observation requires confirmation.

(*Focillinæ*). The palpi are sickle-shaped and long, or are porrect: a frontal tuft is usually present in the latter case. *Simplicia robustalis*, Guen., is a brown moth with the palpi curved over the head, the male antennæ with a tuft of scales at the middle. It has been reared from a brown caterpillar which feeds on dry fallen sissoo leaves (*Dalbergia sissu*); it is a semi-looper, pupating in a light cocoon among leaves or on the soil. *Nodaria extremolis*, Guen., has similar but shorter palpi, and a narrower forewing. *Dichromio erosia*, Cram., has porrect palpi; the hindwing is orange, the forewing grey with a large black triangular patch. *Rhynchina* has porrect palpi, the forewing narrow and acute at the apex. *R. abducalis*, Wlk., is the most common, the forewing with a long dark patch bounded below by an oblique light line running from the apex.

Hypena is a large genus of seventy species, the palpi porrect and of varied length. *H. lividalis*, Hubn.; *H. iconicalis*, Wlk.; *H. obyssiniolis*, Guen. : *H. indicatalis*, Wlk., are the most widespread species; the identification of these and the other forms is possible only if a long series of specimens is available or if they can be compared with accurately identified specimens. A species was reared by de Nicéville on indigo in Champaran (I. M. Notes, V, p. 163).

Hyblæinæ—*Hyblæo puero*, Cram.; and *H. constellata*, Guen., are common where teak (*Tectona grondis*) grows, their larvæ defoliating this tree; the life-history of the former is fully described by R. S. Hole. (Journ. Bo. Nat. Hist. Soc., Vol. XV, p. 679.)

COLLECTING.—Most noctuids are nocturnal and many can be captured at light, some come to sugar (a mixture of treacle or syrup and spirit) and some to ripe fruit. Numbers can be caught in thick grass, on tree bark and in similar situations by day. There is a large field for rearing as only a small percentage are known from the larva and they are, as a rule, easily found and reared. Large numbers of species are as yet undescribed probably and large collections can be made anywhere in India.

PTEROTHYSANIDÆ.

Frenulum absent. Hindwing with vein 8 *approximated to* 7 *at middle of cell.* 1c. *absent. Forewing with vein* 5 *nearer* 4 *than* 6.

This family consists of a single genus (*Pterothysanus*) of moths, found in Assam and Burmah with five doubtful species. They are large diurnal insects, with small upturned palpi, simple antennæ, and long hair fringes to the hindwings. The colouring is vivid black with white and pink blotches on the wings. The larva is unknown and the moths are not common anywhere. None are found in the plains.

LYMANTRIIDÆ.—(*Liparidæ*).

Proboscis aborted. Frenulum present. Forewing with vein 5 nearer 6 than 4. Hindwing with vein 1c., absent, vein 8 connected to the cell by a bar.

This family is common in both the hills and the plains, a number of common species occurring widely in cultivated areas. The moths are of stout build and usually dull colours; the antennæ of the male are pectinate, with spines at the tip of each branch, one of which is oblique and appears to preserve the position of its branch with the next. There is no proboscis and the moths cannot feed. The female is usually characterised by a large anal tuft, which is in some species used as a supply of hair for covering the eggs. The life-history is known in a number of species; the females are usually prolific, laying many eggs in clusters; the larvæ are hairy and are distinguished by the distinct erect tufts of hair on the body; in a number of cases these hairs are poisonous, the point sharp and barbed so that once inserted they remain in the flesh which festers. Such poisonous caterpillars are characteristic of the hills and rare in the plains. Pupation takes place in a loose cocoon of silk and hair, usually on the soil among leaves and debris. The moths fly by night in nearly all cases.

Hibernation appears to be passed in the pupal stage, but more has yet to be learnt of the seasons of these moths. The majority are found in the hot weather and rains, but there are several broods yearly and occasionally larvæ are found in the cold weather. None appear to be definite pests to agriculture, though more than one feeds on cultivated plants, and it is probable that they are checked by parasites to a more marked extent than some other groups.

Hampson lists over 160 species in the Fauna of India and has added 11 since. (Jo. Bo. Nat. Hist. Soc., X, XI, XIII.)

Lælia includes several species, of which *L. exclamationis*, Koll., is most likely to be found. The larva is brown with grey hair and four dorsal tufts of short brown hair. The moth is brown with a single black line on the forewing. *Thiacidas postica*, Wlk., is the very common hairy larva found on the ber tree (*Zizyphus jujuba*). We reproduce the figure from Indian Museum Notes, II, Pl. 2.

Dasychira is an important genus with many species. *D. horsfieldi*, Saund., is the common grey moth found so abundantly in forest localities after the rains; the male is a little over half the size of the female. *D. thwaitesi*, Mo., is mainly a hill or forest form, for which the student should consult Indian Museum Notes, I, p. 29. *Dasychira mendosa*, Hubn., has been reared from larvæ feeding on potato (*Solanum tuberosum*), Mr. de Nicéville reared it on 'desi badam' (*Terminalia catappa*). The moth is dark brown, with a light costa, and the forewing is noticeably drawn out at the apex. This occurs also in *D. securis*, Hnbn., in which the moth is dry grass colour with a central fascia of lilac-grey on the forewing. Its larva feeds on a variety of cultivated plants, including cereals, grasses and cruciferous plants (Plate XXXIX, fig. 7). The pupa is in a thin cocoon of silk and hair, of which one end allows egress to the moth.

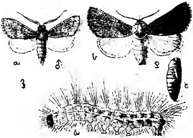


Fig. 313—THIACIDAS POSTICA. A. MALE, B. FEMALE; C. PUPA, D. LARVA (I. M. N.).

Three species of *Lymantria* may be found; *L. incerta*, Wlk., feeds on pipal (*Ficus religiosa*), babul (*Acacia arabica*) and bêr (*Zizyphus jujuba*). Forsayeth describes the larva as light brown with creamy variegations and dark markings. *L. ampla*, Wlk., was reared by de Nicéville on country almond (*Terminalia catappa*) (Ind. Mus. Notes, V, p. 108), and feeds also on pipal (*Ficus religiosa*).

Porthesia xanthorhœa, Koll., is a small white moth with fuscous hindwings in the male, and a large yellow anal tuft. The caterpillar

(Plate XXVIII, fig. 8), is orange with black marks and with hair tufts on each side. It pupates in a cocoon of silk and hair; the foodplants include cane, juar, bajra, marua (*Eleusine coracana*), guinea grass and other cereals, and the moth is common in the plains. It has a habit of sitting by day exposed on plants and grasses as does *Scirpophaga auriflua* which it closely resembles. This species is not known to occur in abundance at any time and is not injurious.

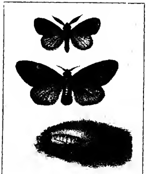


Fig. 314—EUPROCTIS FRATERNA ; MALE ABOVE, FEMALE BELOW, AND PUPA IN COCOON (I. M. N.).

Euproctis includes a large number of small to moderate-sized white, yellow, brown or orange moths which are probably not really as numerous in distinct species as authors now state. *E. lunata*, Wlk., is said to feed on babul (*Acacia arabica*), bér (*Zizyphus jujuba*) and rose. *E. scintillans*, Wlk., feeds on linseed, bhindi (*Hibiscus esculentus*), bajra (*Pennisetum typhoideum*), and probably other plants, and is recorded as destroying mango in Poona (Indian Museum Notes, II, p. 38), and *Terminalia catappa* in Calcutta (loc. cit. V, 108). *E. fraterna*, Mo.. feeds on rose and castor, *E. icilia*, Stoll. (Plate XXXIX, figs. 5. 6), on the common *Loranthus* on trees. These are common throughout India, as well as, *E. semisignata*, Wlk.. *E. flavinata*, Wlk., *E. digramma*, Guér., *E. flava*, F. (*guttata*. Wlk.) The last is the species so destructive to fruit trees of all kinds in the Punjab, the caterpillars sometimes occurring in great abundance in the Canal Colonies. *E. dama*, Swinh.. is a small yellowish species found very commonly; its caterpillar feeds on Kakaronda (*Blume abalsamifera*).

The larva of *Perina nuda*. F., feeds on Kanthal (*Artocarpus integrifolia*), and is common throughout India. A description of the larva will be found in Indian Museum Notes, IV, p. 14.

Leucoma submarginata, Wlk., is also common, a pure white moth with a single black " comma " on the forewing and yellow on the frons, palpi and fore coxæ. Its ally, *L. subvitrea*, Wlk., was reared by de Nicéville on desi badam (*Terminalia catappa*), and is figured (Indian Museum Notes, V, Pl. XI).

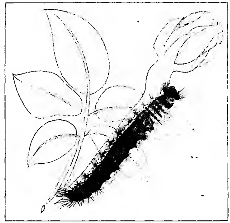


Fig. 315—EUPROCTIS FRATERNA LARVA × 2.

HYPSIDÆ.

Proboscis well developed : hindwing with vein 8 connected to cell by a bar, 1c. absent ; frenulum present. Forewing, vein 5 nearer to 4 than 6.

A small and unimportant family whose species (27) are mainly confined to the hills, but a few of which are common and widespread in the plains and cultivated areas. They are of moderate size and usually bright colouring, rather weak on the wing and sometimes seen flying by day. The colouring is conspicuous enough for any common species to be easily recognised when once seen and is presumably warning in function.

PLATE XXXIX.—Hypsids and Lymantriids.

Fig. 1. *Hypsa ficus*, larva (Hypsidæ).
,, 2. ,, ,, cocoon ,,
,, 3. ,, *alciphron*, larva ,,
,, 4. ,, ,, imago ,,
,, 5. *Euproctis icilia*, larva (Lymantriidæ).
,, 6. ,, ,, imago ,,
,, 7. *Dasychira securis*, larva ,,
,, 8. *Argina argus*, larva (Hypsidæ).
,, 9. ,, ,, imago ,,

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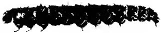
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The life-history presents few points of interest. Eggs are laid singly or in clusters on the foodplant and the larvæ have five pairs of sucker-feet, are brightly coloured and sparsely clothed with hair. They feed openly on the leaves by day and are possibly distasteful to the majority of birds. Pupation takes place in a slight cocoon in rolled leaves on the soil. So far as is known, hibernation is passed as a pupa in the soil, and there are several broods yearly commencing in the hot weather if food is available. Two species are pests to agriculture and at least two injure trees, so the family has some economic importance.

Hypsa is a genus of rather large moths, the palpi upturned, the apical joint slender and reaching above the head. The antennæ are fasciculate in the male, ciliate in the female. Two species are very common in the plains, the larvæ feeding on pipal, pakur and other species of *Ficus* grown as shade trees (Plate XXXIX); the caterpillars are sometimes so abundant that they defoliate large trees and, standing below an infested tree, one hears their excrements falling in a continuous shower like rain. We figure the moth of *H. alciphron*, Cram., from which *H. ficus*, Fabr., differs in markings; both are dull ochreous with yellow and black markings at the base of the wing.

Digama hearseyana, Mo., is common throughout the hill and forest areas in India but is rarely found in the cultivated plains. It is a small moth, the forewing dusky with dark spots, the hindwing orange. It has a very neat trim appearance and is one of the very common moths one first sees and captures in the hills. Two genera, *Nyctemera* and *Argina*, formerly placed in *Arctiidæ* are now classed with *Hypsa*. Of the former. three species, *N. lacticinia*, Cram., *N. latistriga*. Wlk., and *N. plagifera*, Wlk., are large moths, white and brown in colour, which occur throughout the hill and forest areas of India and are found rarely in the plains. Of the latter, three species occur throughout India including the plains, feeding on Sann Hemp (*Crotalaria juncea*) and wild *Crotalaria*. All are bright coloured moths, the forewing with ringed black spots; *A. argus*, Koll., has the forewing brownish red, the hindwing scarlet, the larva is common in the pods. feeding on the seeds. (Plate **XXXIX**, figs. 8, 9.) *A. syringa*, Cram., has the forewing pinkish brown and clouded with fuscous, the hindwing crimson. while *A. cribraria*. Clerck., has the ground colour orange. The last is the most common, its larva a serious pest occasionally, feeding mainly on leaves (see Agric. Journ. I, No. 3).

SPHINGIDÆ.—*Hawk Moths.*

Antennæ fusiform, thickened towards the apex and slightly hooked. Forewing long and narrow, vein 5 nearer 6 than 4 or from the middle of the cell; hindwing vein 8 connected to the cell by a bar at the base, then approximated to or anastomosing with 7, vein 1c. absent. Frenulum present. Pupa in soil, larva smooth with anal horn.

The narrow forewings, the spindle-shaped hooked antennæ, the usually torpedo-shaped body and the swift flight enable this family to

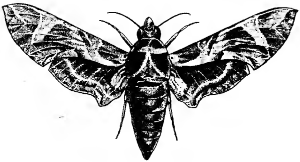

Fig. 316—DAPHNIS NERII.

be readily recognised in the field. The moths are moderate to large in size, with an expanse of one to four inches. The colouring is uniform in design, but diverse and marked in individual species. The body and forewings are cryptically coloured in shades of brown, grey and dull green, which make the insect invisible when resting on bark or on other exposed positions. The lower wing and sometimes part of the base of the abdomen is brightly coloured, the resting attitude being such that the forewing covers the brightly coloured parts, which are visible only in flight. The object of the bright colouring, usually

PLATE XL.—ACHERONTIA STYX.

TIL SPHINX.

Fig. 1. Eggs.
" 2. Young larva.
" 3. } Half-grown larva.
" 4. }
" 5. Full-grown larva. Natural size.
" 6. Pupa.
" 7. Moth

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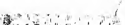

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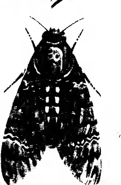

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red or orange, is probably deceptive, the whole scheme being similar to that of the Acridiidæ and other insects which exhibit this peculiar colour scheme. (See under Acridiidæ.)

The head is large with large compound eyes; the proboscis is usually very long, tightly curled up in repose and stiffly extended to its full length when the moth hovers before a flower. The antennæ are straight, a little smaller towards the apex, slightly hooked, and in the male with curious tufts of cilia on the lower side.

The thorax is robust, the outline of the whole body from head to apex of abdomen smooth and tapering to each end; the abdomen is long, in some species with lateral and terminal tufts of erectile hairs. The forewing is long and narrow, the hindwing smaller. Males and females are similar in colouring, the males smaller and distinguished by the antennæ.

The life-history is uniform in all but detail so far as known. Eggs are laid singly on the leaves of the foodplant, each egg circular with the micropyle at the apex. The larvæ grow to a considerable size, some exceeding three inches in length; there are five pairs of suckerfeet, and usually a horn on the 8th abdominal segment. The integument is smooth, or more rarely, roughened with numerous tiny blunt spines: none are hairy or tufted; the head is either large and distinct, or small and retractile into the prothorax, which is drawn back with the meso and metathorax. The colouring is usually green or brown, cryptic, and often with lateral yellow stripes which increase the cryptic resemblance. In many, there are in addition devices which are evidently meant to be terrifying; such are the eye spots, large coloured spots on the sides of the thorax which look like large real eyes when the head is drawn in: the appearance of the insect with these eyes is very striking and in some there is, to us, a suggestion of the snake. In some these spots are concealed and can be suddenly shown, when the effect is still more striking. As a whole the larvæ exhibit cryptic colouring combined with terrifying devices. An interesting adaptation is found in the change of colour which often takes place at the close of the larval life; hitherto the green caterpillar, for instance, has been concealed by its colour among the leaves of its foodplant: prior to pupation it must leave its foodplant and crawl over the soil, perhaps after a journey down the bark of a tree, to find a suitable place to hide itself for pupation.

The green colour would then be very conspicuous on the soil or bark, and we find that the upper surface of the body darkens in tint till it, and perhaps the whole body becomes brown when the insect has to pupate. It then crawls away till it finds a suitable shelter in soil or among fallen leaves, etc., where it pupates. As a rule, coarse threads of silk are used to form a covering with leaves and debris, or the caterpillar forms a chamber in which to pupate : from the time the caterpillar ceases feeding till it actually transforms to the pupa as much as a week may elapse, during which the caterpillar is internally and externally preparing for the last moult.

The caterpillars are wholly herbivorous, feeding on the leaves of their foodplants which usually embrace a few allied species. They feed usually in the morning and evening only. The pupa is a large brown object, of two forms, one with an external proboscis sheath (as in *Herse convolvuli*) the other without (as in *Acherontia styx*).

The moths are usually crepuscular, the smaller " humming bird hawks " being alone seen flying by day. Food is the nectar extracted from flowers, the moth hovering before the flower, the long proboscis being inserted to suck it out ; white flowers that bloom at night attract these moths and it is a wonderful sight to watch such plants when large numbers of the moths come. *Quisqualis indica* is a favourite flower, being white at night to attract these moths, though it is red by day.

The moths are extraordinarily swift of flight and very powerful ; it is possibly due to this that they form so large a proportion of the insect fauna of the island of Barbados in the West Indies, a fact not yet recorded by any naturalist ; this island is low and wind swept, less than 20 miles across and any but a strong flying moth is liable to be blown away by the tradewinds, just as large numbers of insects are sometimes blown on to the island ; apparently the hawkmoths have been able to remain on the island, and they constitute an extraordinarily large proportion of the insect fauna.

The duration of the larval stage is relatively long, the larger species requiring two months to become full-grown, the pupal stage then being moderately long and the imaginal life shorter. Hibernation takes place as a pupa in the soil and no cases of larval or imaginal hibernation are known ; equally æstivation is passed as a pupa, unless it be one of the species whose food is then available.

As a rule there are two broods during the rains, with pupal hibernation in the second until March or June, more often the latter. Few are pests since they are insects that increase but slowly, but a few are found feeding on cultivated plants and are occasionally numerous.

The larvæ are parasitised by parasitic Hymenoptera and Diptera as are other caterpillars, and these parasites are the chief check. Birds readily eat the caterpillars when they find them, and help to check them when they are numerous.

Hampson lists 121 Indian species, mostly hill forms not recorded from the plains. A few species are common in the plains, a number more are recorded and will be found widespread. Jordan and Rothschild list 154 (1907); their revision alters practically the whole nomenclature and classification, and brings in the greatest possible amount of confusion. In the present deplorable state of entomology, their nomenclature will probably be adopted till another replaces it, and we accordingly use both here. The most recent account is that of these authors in Genera Insectorum, which is a revision of their earlier revision. The authors are extremely vague about geographical distribution, and it is impossible to be certain exactly which species actually occur in India.

Acherontiinæ—*Herse* (Protoparce) *convolvuli*, Linn., is our commonest form, a large grey moth with pink bands on the abdomen, which comes freely to light. The larva feeds on sweet potato, urid (*Phaseolus mungo*), and on convolvulaceous creepers. The pupa is in a hard earthen chamber.

Acherontia styx, Westw., is our death's-head moth, so-called from the skull-mark on the thorax. This is the tropical and sub-tropical form of *A. lachesis*, Fabr., found only in the Himalayas. The large green caterpillar is found on til (*Sesamum indicum*) and kulthi (*Dolichos lablab*). There are probably two broods a year in all parts of the plains, the pupa living over the winter (Plate XL).

Psilogramma menephron, Cram. (Pseudosphinx discistriga, Wlk.), is a large grey moth with an expanse of 3½ to 5½ inches, less common but widely spread in the plains.

Ambulycinæ.—*Compsogene* (Calymnia) *panopus*, Cram., is the very large purple and brown moth, with a wing expanse of 5½ inches. The larva is grey with yellow stripes, the anal process long and straight; it feeds on the leaf of mango. *Oxyambulyx subocellata.* Feld (Ambulyx semifervens, Wlk.) is widespread in India while the larva of *Clanis phalaris*, Fabr. (*Ambulyx pagana*, F.) is described (under *Clanis cervina*) by Forsayeth as feeding on the dhak or palas tree (*Butea frondosa*), (Trans. Ent. Soc., London, 1884, p. 393). *Leucophlebia emittens*, Wlk., and *L. lineata*, Wlk., are the beautiful pink moths with a yellow fascia along the forewing, which so often come to light in India. The larva of *Polyptychus trilineatus*, Mo. (*dentatus*, Cram.), is said by Forsayeth (*loc. cit.*) to feed on lasora (*Cordia myxa*).

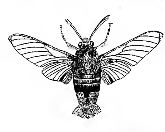
Fig. 317—Cephonodes hylas

Sesiinæ. Cephonodes hylas, Linn., is the common "humming bird hawk moth" of the plains, a beautiful moth with yellow and red abdomen and a spreading black anal tuft, which comes in dull weather and at dusk and flies softly through shrubs seeking flowers; it is a shy insect, hard to see or catch, with a distinctive deep hum in flight.

Philampelinæ. Deilephila (Daphnis) *nerii*, Linn., is the beautiful dark olive-green and pink moth (fig. 314) whose larva feeds on the Oleander; *D. hypothous*, Cram., also occurs in our limits. *Nephele didyma*, Fabr. (*hespera*, F.) is a smaller olive-green moth, reared in Calcutta on Karunda (*Carissa Carandas*) (Indian Mus. Notes, V, p. 126).

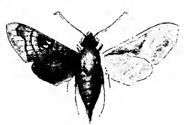
Fig. 318—Nephele didyma (I. M. N.).

Macroglossum includes dark coloured "humming bird hawk moths," found flying by day in bushes seeking flowers; they are extremely abundant in the subtropical zone but some occur in the plains. *M. gyrans*, Wlk.; *M. belis*, Cram.; and *M. pyrrosticta*, Butl. (*gilia*, Herr. Sch.) are to be found, the second most abundantly.

Chærocampinæ.—A number of common forms are included in this sub-family. The larvæ have the head and thoracic segments more or less retractile into the swollen metathorax, which often has lateral eye-marks. In *Hippotion celerio*, L., the larvæ may be green or dark brown, both occurring together in all stages on the same foodplant. The genera *Theretra* and *Hippotion* include the common hawkmoths of the plains, moderate sized insects with the apex of the forewing produced slightly. The full fed larva pupates at the surface of the soil in a covering of leaves webbed up with coarse silk enclosing an earthen chamber.

The following are the common species, with the revised and old nomenclature of the Fauna, and the known foodplants in India.

Theretra gnoma, Fabr.	(Chærocampa butus, Cram.)	Grape vine.
,, *alecto*, Linn.	(Chærocampa).	Peas, Teak, *Vitis trifolia*.
,, *oldenlandiæ*, Fabr.	(Chærocampa).	Balsam, *Vitis trifolia*
,, *silhetensis*, Wlk.	(Chærocampa).	
,, *latreillei*, Macl.	(Chærocampa lucasi, Wlk.)	
,, *nessus*, Fabr.		
Hippotion echeclus, Boisd.	(Chærocampa eson, Cram.)	Sesamum.
,, *rafflesi*, Butl.	(Chærocampa theylia, Linn.)	
,, *celerio*, Linn.	(Chærocampa).	Balsam and *Beta vulgaris*.
,, *velox*, Fabr.	(Chærocampa vigil, Guer).	
Rhyncholaba acteus, Cram.	(Theretra).	

Collecting.—Moths are caught on the wing by day (*Macroglossinæ*) or at dusk at flowers. Some come to light and the occurrence of these is worth noting even if they be common species. Larvæ are always worth rearing if their food plant can be ascertained, and there is no special difficulty in this. If it is desired to obtain eggs, the pupæ must all be treated alike as they react quickly to altered conditions and will not emerge together if differently treated.

CYMATOPHORIDÆ.

Characters of Sphingidæ but vein 8 not connected with 7.

A family of 22 moths found in the Himalayas, Khasis and Burmah Hills, and which are absent from tropical India. They are in appearance like Noctuids while the larva has five pairs of suckerfeet and is not clothed with hair. No species will be found in the plains.

EUPTEROTIDÆ.

Frenulum present, proboscis absent. Forewing with vein 5 nearer 6 than 4. Hindwing with vein 8 remote from vein 7, vein 1c. absent. Larva uniformly hairy, pupa in cocoon of silk and hair.

This is a family of large moths with hairy palpi, the antennæ pectinated in both sexes, the mid-tibia with one pair, the hind tibiæ with two pairs of spurs. They are dull coloured moths, principally found in hill forest areas, of which 42 species are recorded as "Indian."

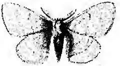

Fig. 319—Eupterote minor, male.

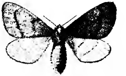

Fig. 320—Eupterote minor, female.

The larvæ are found, in great numbers occasionally, feeding upon forest trees. They are uniformly hairy, with five pairs of suckerfeet. The larvæ are gregarious, feeding together on the plant. The hairs are poisonous and are readily detached either when the larva is irritated or touched, and these hairs become firmly fixed in the skin giving rise to great irritation. The pupa is in a cocoon of silk and hair. Hibernation in the cocoon takes place from the end of the rains to the following rains.

Eupterote is the abundant genus, with several species common in the moister and more densely forested parts of India. *E. undata*, Blanch., occurs throughout North India and as far south as the Nilgiris; it varies much in colouring from pale brown or yellow suffused with brown to deep red-brown: each wing has a varying number of waved lines; *E. fabia*, Cram., is not regarded by Hampson as a distinct species; the male has the forewing bright yellow. In both, the expanse ranges from three to five inches. *E. mollifera*, Wlk., is smaller, 2½ to 3½ inches with the ground colour always yellow or dark, often suffused with rufous. It occurs in South India. *E. citrina*, Wlk., is uniform yellowish white, with the head and prothorax fuscous in the male, the female with raised scales at the outer angle of the forewing below and the apex of the hindwing above. Its distribution is given as the Deccan, Central India and Bombay.

Of these *E. undata* was reared by de Nicéville in Calcutta, on *Erythrina indica*, with one brood yearly apparently. (I. M. N., V, p. 129.)*E. minor*, Mo., was reared from caterpillars which appeared in great numbers in Burmah " destroying the herbage and swarming on the roads to such an extent that thousands of them must be trodden under foot by passing way-farers. " (I. M. N., Vol. III, p. 21.)

Sangatissa subcurvifera, Wlk., is pale brown, the forewing with the three curved dark bands obliquely along it. It occurs in the North-West Himalayas, in South India, and has been found in the Gangetic plain *Nisaga simplex*, Wlk., varies much in colour, the wings yellow to deep brown, with lines of dark scales along the veins. It has been reared from a yellow-marked black caterpillar, moderately hairy, found feeding on rice in Ranchi and on grass in Pachmarhi, Central Provinces, and it is common also in Assam and South India. It hibernates in the cocoon from October-November to June.

NOTODONTIDÆ.

Hindwing with vein 8 connected to 7 near middle of cell. Vein 5 obsolescent, 1c. absent. Proboscis present. Forewing with vein 5 nearer 6 than 4.

A family of moths, recognisable by their venation alone, and superficially like *Noctuidæ*, or in some cases, *Sphingidæ*. The colours are dull, greys and browns predominating. The antennæ are often pectinate, the abdomen long and tapering, terminating in some in long scales or tufts. **Many** are of large size with an expanse in some instances of over four inches. Nearly all are hill forms, confined to high elevations; the family is a very large one in temperate climates, and there are 120 species listed as from the Indian region of which four alone are common in our area; 21 have been since added by Hampson.

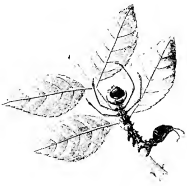

Fig. 321—STAUROPUS ALTERNUS, LARVA ON ROSE LEAF.

Antheua servula, Dr., is a yellow moth, with a brown patch and rufous margin on the forewing. The larva is brown clothed in brown hair; it feeds on grass, pupating in the soil. *Stauropus alternus*, Wlk., is a grey moth, the forewing rather narrow, the abdomen long. The male has pectinate antennæ. We figure the larva (fig. 321) which is of the form characteristic of some Notodontids, destitute of anal prolegs, holding the apex of the abdomen in the air, with processes on the dorsal surface. This device is to protect the insect by its alarming appearance. The grey moth rests with the costal margin of the hindwing projecting in front of the forewing, after the manner of a Lasiocampid moth. The larva has been found feeding upon pigeon pea (*Cajanus indicus*).

Anticyra combusta, Wlk., has been reared from a larva found feeding upon maize. This larva is 2½ inches long, of a whitish green colour with white intersegmental bands, and a lateral green stripe; there are short white hairs laterally; the prolegs are normal, 5 pairs. Pupation

PLATE XLI.—GEOMETRIDÆ AND LASIOCAMPIDÆ.

Fig.	1.	Eumelea rosalia.		(Geometridæ)
,,	2.	Macaria fasciata		,,
,,	3.	Tephrina disputaria.	Larva.	,,
,,	4.	,, ,,	Pupa.	,,
,,	5.	,, ,,	Imago.	,,
,,	6.	Hypererythra phœnix		,,
,,	7.	Thalassodes quadraria.		,,
,,	8.	Taragama siva.	Larva.	(Lasiocampidæ).
,,	9.	,, ,,	Cocoon.	,,
,,	10	,, ,,	Male.	,,
,,	11.	,, ,,	Female.	,,
,,	12.	Estigena pardalis.		,,

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takes place in the soil without a cocoon and lasts 13 days. The moth is "dry grass colour" with a median purplish suffusion: it sits with its wings rolled round it, and very closely resembles a piece of maize stem cut from a node, with a piece of dry leaf round it; the head looks like the dry bluntly-cut node and the whole resemblance is singularly perfect and striking.

GEOMETRIDÆ.

Vein 5 nearer 6 than 4 in forewing. Hindwing vein 8 connected with 7 at the base or if not, vein 5 fully developed; vein 1c. absent. Proboscis present.

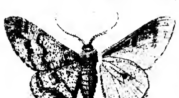

Fig. 322--BISTON SUPPRESSARIA. (I. M. N.)

There is a general family resemblance among our common Geometers but the venation affords the sole accurate characters. They are frenulate moths with the proboscis developed, with the venation as above, and the tarsi usually long and naked. They are of moderate to large size with cryptic colouring in nearly all cases.

The life-history of but few has been worked out in this country: the known larvæ are loopers, with two pairs of prolegs, the body nearly naked and slender. As a rule a true looper is at once recognisable from it attitude and general form (Plate XLI. fig. 3): the attitude with the

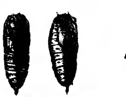

Fig. 323--BISTON SUPPRESSARIA. (I. M. N.)

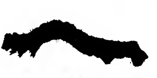

Fig. 324--BISTON SUPPRESSARIA. (I. M. N.)

colouring is often beautifully cryptic, the larva remaining stiffly stretched out at an angle, the suckerfeet clasped round a twig, and the whole looking like a small shoot or twig and quite unlike a living insect.

The moths are crepuscular as a rule and but rarely seen, or are found in thick vegetation and under shade. They have a habit of resting with fully opened wings tightly pressed against the surface they are on; the colouration is adapted to this, the markings continuous from fore to hind wing; in this attitude they are difficult to distinguish and they will rest thus during the whole day if undisturbed. They seldom occur in any great abundance and the larvæ are very seldom found. None is known to be of any economic importance in India. The family is a very large one (1,300 species in the Indian region) and additions are constantly being made to it. Nearly all are hill and forest forms, few living in the plains.

Hampson divides the family into 6 sub-families, the key to which is on page 138 of volume III of moths in the Fauna of India.

Boarmiinæ.—Hindwing with vein 5 obsolete.

Dilinia capitata, Wlk., is a common species whose larva feeds on ber (*Zizyphus jujuba*). The larva is green above, greenish-white below with the usual two pairs of suckerfeet; seen from above it is of the colour of the upper surface of the leaves, seen from below of the colour of leaves looked at from below, a colouring common in leaf-eating caterpillars and doubly cryptic. Pupation takes place between two leaves fastened with white silk; the period is about a week.

Macaria fasciata, Fabr. (Plate XLI, fig. 2), is common, the larva green or brown with dorsal and sublateral yellow stripes, found feeding on the flowers of *Acacia concinna*. *M. nora*, Wlk., *M. sufflata*, Guen,, and *M. emersaria*, Wlk., are also likely to be found.

Tephrina is the most abundant Geometrid in the plains, *T. disputaria*, Guen., being the little browny-white moth so common in grass. The larva feeds on babul (*Acacia arabica*) and may be found wherever this tree grows (Plate XLI). *Hyposidra talaca*, Wlk., is another plains species, the larva green irrorated with black, with the 1st and 3rd abdominal segments dark, the recorded foodplants are *Jambora*, *Combretus*, *Ficus parasiticus* and rose.

Orthostixinæ.—The beautiful *Eumelea rosalia*, Cram., is found in the plains (Plate XLI, fig. 1).

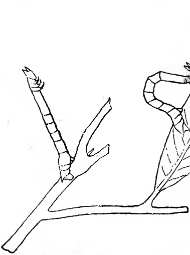

Fig. 325—THALASSODES QUADRARIA, LARVA ON LITCHI.

Acidaliinæ.—A number of species are widespread in the forest areas of India and less than ten are known from the plains.

Geometrinæ.—*Agathia lycænaria*, Koll., is said to feed on *Nerium odorum* (Grote). *Thalassodes quadraria*, Guen., has been reared from larvæ feeding upon the leaves of litchi (*Nephelium lichi*) and also on maize. The larva is green with a pair of orange processes on the head. (Plate XLI, fig. 7.)

SATURNIIDÆ.—*Wild Silk Moths.*

Forewing with vein 7 connected to 8 and 9. Hind wing with vein 8 diverging from cell from the base. Forewing with vein 5 nearer 6 than 4. Hindwing vein 1c. absent. Larva with conspicuous spiny processes; pupa in cocoon of silk.

These insects are commonly recognisable in all stages. The moths are of large size, the immense Atlas Moth having a span of ten inches. The colouring is bright and very varied in tint; it has no protective significance in all probability and the resemblance to the head of the cobra seen by some authors in the apex of the wing of some species does not appear to have any real significance; in some species there are clear circular spots in the wings. The body is short and thickset, densely clothed in hair, the legs are short, the wings very large. The absence of proboscis makes feeding impossible and the moths are not long-lived.

The moths deposit large numbers of round eggs (Plate XLII), which are thickshelled, without ornamentation and in some cases laid with a coating of gum which makes them adhere in groups. The larvæ grow to a large size, and are characterised by having tubercles or processes bearing spines; they are leaf-eating and found principally upon forest trees. When full grown a cocoon is spun, composed of more or less tightly woven silk fixed to a leaf or some other part of the plant. Emergence from the cocoon is effected by softening one end of the cocoon by a solvent fluid excreted by the pupa or by the passage of the moth through one end which is so constructed as to allow of the egress of the moth but not of the entrance of insects from without (see page 481).

The moths are nocturnal and short lived; the phenomenon of assembling is conspicuous and is utilised by native silk rearers, who keep only the heavier female cocoons for rearing females; these females are then exposed at night, fastened down, and are fertilised by wild males which come from the surrounding forests. "Assembling" denotes the attraction of the males to females by some sense, possibly that of smell which guides them from a long distance; it is employed in collecting certain butterflies and moths which exhibit this faculty, the exposure of a newly hatched female being sufficient to bring up the males in the vicinity. It occurs only in Lepidoptera in this marked form.

None of these species can be considered as pests, while the species producing tasar, eri and muga silk rank in economic value beside the true silkworm (*Bombyx mori*, L.) and the lac insect (*Tachardia lacca*). These insects are wholly confined to moist forest areas, the larvæ usually feeding upon forest trees and not thriving when exposed to hot dry west winds. For this reason it is impossible to rear them throughout India, and though some will feed on cultivated plants such as castor.

these are not cultivated outside limited areas in which the insects occur naturally.

The family is not a large one and the thirty odd Indian species are almost wholly confined to the moist hill forest areas. *Actias*, *Attacus* and *Antheræa* are the principal genera and the variation in colour of the moths has led to their being described under a variety of names, Hampson's classification in the Fauna of India reducing many of these doubtful species to synonyms. The student should familiarise himself with these synonyms before reading the past literature of these insects in which a variety of names are employed for the few economically important species. The following list embodies the species of Wild Silk Moths referred to by Cotes (Ind. Mus. Notes, Vol. II, No. 2) and figured by him; these are insects which make silk in some quantity but only three are actually reared for silk or produce a silk used in commerce. We have included the Bombycids, etc., in this list.

Attacus	*atlas*, Linn.	The Atlas Moth.
,,	*edwardsi*, Wh.	
,,	*cynthia*, Dr.	The wild form of *A. ricini*.
,,	*ricini*, Boisd.	The eri silkworm of Assam.
Actias	*selene*, Hubn.	
,,	*mænas*, Dubl.	(=*Actias leto*, Dubl.)
Antheræa	*frithi*, Mo.	
,,	*helferi*, Mo.	
,,	*roylei*, Mo.	
,,	*assama*, Westw.	The muga moth of Assam.
,,	*paphia*, Linn.	The tasar moth (= *A. mylitta*, Dr.)
,,	*knyvetti*, Hamps.	
,,	*andamana*, Mo.	
Cricula	*trifenestrata*, Helf.	
,,	*drepanoides*, Mo.	
Loepa	*newara*, Mo.	(*Rhodia*).
,,	*katinka*, Westw.	(*L. sikkima*, Mo., *L. miranda*, Mo.)
Saturnia	*stoliczkana*, Feld.	
,,	*pyretorum*, Westw.	(*S. cidosa*, Mo.)
,,	*grotei*, Mo.	
,,	*huttoni*, Mo.	(*Neoris*.)
,,	*simla*, Westw.	(*Caligula*.)

Saturnia	*thibeta*, Westw.	(*Caligula.*)
,,	*zuleika*, Ho.	(*Rinaca.*)
Salassa	*lola*, Westw.	
,,	*royi*, Elw.	
Brahmæa	*wallichii*, Gr.	(= *B. certhia*, F.)
Theophila	*huttoni*, Westw.	(*religiosa*, Helf., *bengalensis*, Hutt. *affinis*, Hutt., *sherwilli*, Hutt.)
Ocinara	*varians*, Wlk.	*Trilocha albicollis*, Wlk.
,,	*apicalis*, Wlk.	*O. lida*, Mo.
,,	*signifera*, Wlk.	*O. lactea*, Hutt., *O. diaphana*, Mo.

Actias selene, Hubn., is a very striking insect, the forewing is large, the hindwing produced into a long tail; the colour is a delicate pale

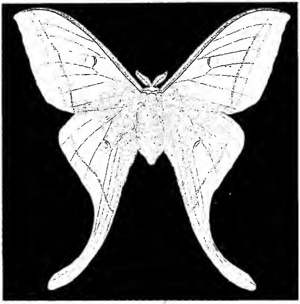

Fig. 326—ACTIAS SELENE. × ⅔.

green, the forewing having a dark pink fore edge; in each wing is a buff and red spot. The larva is green with yellow tubercles bearing spines. The species is widely spread over the hill forest areas in India, at low elevations often, but is typically a subtropical and only occasionally a plains species (*e.g.*, in Chota Nagpur).

Attacus atlas, Linn. (The Atlas Moth), is the largest Indian Moth, a very beautiful vividly coloured insect found in hilly forest districts. Its life-history is described by Grote (Entomologist XII, p. 25) and an account of it occurs in Hardiman's "Silk in Burmah." *Attacus cynthia*, Dr., is stated to be the eri silk of Assam, as also is *Attacus ricini*, Boisd., the two differing only in colouring and very slightly in markings. Moths reared from true eri cocoons cultivated in Assam proved to be the latter (Plate XLIV). The lifehistory has been fully described elsewhere and there is a literature on this insect. Like others of this family it is wholly dependent upon moist conditions; the larvæ exhibit a curious variation, some being green, some white, some being spotted with black, others not; the cocoons are white or brick-red but selection fixes the latter, while it does not influence the larval colour or spotting.

Antheræa includes the tasar silk moth (*A. paphia*, Linn.) and the muga silk moth (*A. Assama*, Westw.). The former makes a cocoon usually of the form shown, fastened by a stalk, the latter a simpler oval cocoon. Tasar is collected in many forest areas in India and is a very important industry, muga is semi-cultivated in Assam, and forms the basis of an industry there.

The tasar silkworm (Plates XLII, XLIII) is not a domesticated insect at all, it feeds upon trees or bushes in the open entirely and the sources of silk are either of purely wild cocoons collected by cow-herds when the trees are leafless and they can be seen, or cocoons formed on special trees by worms which were hatched on that tree from eggs laid in captivity, the rearer having kept cocoons till the moths emerged. In this species, the females alone are kept, the males are allowed to fly away and mating takes place at dusk with any male that comes. There are in tusser a number of varieties or races, some two-brooded, some one-brooded; the entire absence of any control over this mating, so far as the male is concerned, is probably one cause of the degeneration of the tasar industry, since a female of a race that spins good marketable cocoons may be crossed with a male of a poor race, and the crossing of a bivoltine race with a univoltine probably causes the irregular éclosion of moths that is such a handicap to the rearer.

The different races have distinct periods of éclosion; there is a brood usually in July-August, followed by a brood in October-November in some; some éclose in September and are one brooded, some in July or June with one brood. Owing to the failure to domesticate fully, the variety of races which cross and the entire lack of control of fertilisation, there is no distinct pure race that can be grown in domestication, and were tasar to be improved or the industry revived under an increased demand, these factors must be taken into account.

Tasar is found on a great variety of trees, the asan (*Terminalia tomentosa*), the Urjun (*T. arjuna*), the sal (*Shorea robusta*), the bér (*Zizyphus jujuba*) being the more important; in gardens, it feeds on *Lagerstrœmia indica*. The cocoon is very dense and hard in some races with a long or short peduncle. As a rule, the summer cocoon is flimsier than the winter cocoon where there are two races. The silk is a reelable silk as in Bombyx silk and the moth must not be permitted to emerge, as the end of the cocoon is softened with alkali, then torn by the exit of the moth.

The stages are figured on Plate XLII. The larva has the most beautiful metallic spots, silver or a reddish gold tinge; it is cryptically coloured, being leaf green, resting in a very characteristic attitude and possibly the metallic spots represent spots of light coming through leaves. The tusser worm is attacked by many foes and a very low percentage pass through their stages and attain maturity, even when the larger enemies are kept away; the possible rate of increase is a hundred fold, each pair producing about 200 eggs; not more than a tenth of this is actually realised. Wasps (*Vespa* and *Polistes*) feed on them; *Canthecona furcellata*, a Pentatomid bug, sucks them; *Mantids* eat them, birds, bats, lizards all eat them and a Tachinid fly parasitises them. The literature is extensive, but Cotes' articles on the Domesticated and the wild silks of India give useful information and are well illustrated.

The student may be cautioned against accepting some of the literature as accurate; notably much is said as to the possibility of the extension of silk cultivation in India by English writers ignorant of the fact that this is purely a matter of climate; it is impossible to grow any kind of silk profitably unless the climate is suitable, which it is only in well defined tracts for each species. It must also be remembered that the production of a textile fibre from silk caterpillars of whatever kind requires primarily an abundant supply of absolutely cheap labour in whom the occupation is hereditary; given all other conditions, a suitable equable moist climate, a healthy race, a supply of food-plant, and a demand for the fibre, silk as an industry cannot be carried on except by low-paid people to whom the occupation comes naturally from childhood; it has never and will never be carried on in countries where living is dear or where labour finds high wages, unless the demand for silk increases; no insect fibre can be produced at the low cost of a vegetable fibre; the lowest price for a pure silk (£120 a ton for eri cocoons) is above the price of all vegetable fibres excepting that of the very best flax which reaches this price in some years. The attempts to grow silk in the United States for instance have all ended in failure for this reason.

Cricula trifenestrata, Helf., is the only species which can properly be brought within the fauna of the plains of India. Its caterpillar lives upon the mango tree in lower Bengal and Burma: it is clothed in poisonous spines and therefore dangerous to handle; Mr. Jamini Mohan Ghose informs me that it is a common belief in Mymensingh that if the mouth touches any portion of the human body, that part will decay as in leprosy; the caterpillar is accordingly feared and nothing is done to check it, though it wholly defoliates the mango tree. Attempts to make an industry in it, for spun silk, have been made in Burma (Silk in Burma, J. P. Hardiman, p. 20).

EMERGENCE FROM THE COCOON.

Very little attention has been paid to that one moment in the lives of so many insects when the imago emerges from the pupa and has to make its way out of the cocoon or other pupal envelope. If the cocoon or covering is sufficiently perfect to resist the weather and the foes of the pupa, how is the usually soft and delicate insect to escape? We have not space here to discuss this exhaustively, nor are the data available for many Indian insects; we indicate some of the commonest methods chiefly in order to direct the attention of the student to this neglected point.

In the first place we find that in some species the pupa is provided with means of forcing itself out, so that the imago can emerge free to the open air. *Micropteryx* is a conspicuous example, in which the pupa has a very large pair of mandibles, with which it cuts through the cocoon and, having done so and forced its way out with the aid of spines on the abdomen, the mandibles are shed. The imago is then free to emerge unimpeded by the cocoon. The same occurs in *Myrmeleo*, in *Hemerobius* and in the *Phryganeides*; (this is only one of the reasons adduced to support the view that *Micropteryx* is closely related to the *Phryganeides*). Actually it is the muscles of the imago which move the large pupal jaws, but the latter are an essential pupal character and absent in the emerged adult. In another group, in which pupal emergence occurs, we find that the pupa has hard processes on the head and that the body is much ciliated to give it a grip on the cell; an instance is the pupa of the Bombyliid, *Anthrax*, parasitic in the nest of mason bees. In several groups of Lepidoptera, the pupa wriggles half way out of the cocoon or shelter and then the imago emerges. This is seen in the male of *Psychidæ* (fig. 328) in many *Sesiidæ* and *Tortricidæ* (Pl. LII), and in *Cossidæ* (fig. 330). In some of these, there are not only abdominal spines, but on the head a strong process used for piercing the cocoon. We may remind the student that the bulk of Heterocerous pupæ are firmly attached to the cocoon by the terminal process and so cannot move out; the families mentioned here are in a minority in utilising the activity of the pupa.

The more general device is some arrangement by which the imago can emerge. One of the most striking is the secretion of solvents which either dissolve or soften the cocoon, releasing the imago. Latter proved the presence in the Puss Moth Cocoon of free Potassium Hydroxide, and further states that the imago is itself protected by a part of the pupa skin when it pushes through the softened cocoon (Trans. Ent. Soc. 1895, p. 399). The same principle is utilised by the silk moth (*Bombyx mori*) and by some *Saturniidæ*. For this reason silk can be reeled only from cocoons from which the moth has not emerged, as the solvent is injurious to the fibres of the silk. In a number of species of *Saturniidæ*, this process is supplemented or replaced by the action of two spines, one on each forewing at the base of the costal edge; the imago emerges with crumpled wings and with the spines projecting forward before the head; these are used to cut through the cocoon and allow the moth to emerge. This occurs in the genera *Saturnia*, *Actias* and *Antheræa*. In *Attacus* this does not occur, but the cocoon is spun with one end closed with thread loops, in such a way that anything trying to get in, forces the loops together, but the moth, emerging from within, forces the loops apart. Similar devices are far more common probably than are now recorded; in *Earias fabia*, for instance, the cocoon is of peculiar shape, and the lips of one end close mechanically; the moth pressing from within escapes easily and the lips gape readily if the cocoon is pressed from above; but it resists any attempts at entrance from without. It would be of great interest to investigate this device in cocoon-making Lepidoptera; it apparently gives place to the simpler device of the less strongly woven cocoon from which the moth escapes by pushing through the loose fibres and hairs at one end; there are probably many transitional stages from this to the stout self-opening cocoon. The Arctiids commonly have loose cocoons as do many *Noctuids*, *Pyralids*, *Tineids*, etc. For these, as for many *Coleoptera*, the body of the pupa is set with backwardly directed spines and a terminal hook to give the moth the necessary purchase to escape.

Finally, there are a great number of stout cocoons in which a definite lid is provided which comes off. *Limacodidæ* are a conspicuous example (fig. 334). In these cases there is a definite line of weakness along the wall of the cocoon and we may admire both the instinct of the larva in providing it and its ability to so make the cocoon. It occurs also in some *Braconidæ*, and in *Cionus* among Curculionidæ. In the latter the larva can be seen through the horny cocoon preparing its shelter and leaving the line of weakness. By what means the emerging imago ruptures the lid is not known, but as little strength is required, there are probably as a rule no special devices. In a great number of species, especially of *Coleoptera*, the imago employs its own jaws. The beetle comes out of the pupal skin, rests till the chitin is hard and then bites through the cocoon or the end of the gallery in which it may be and so emerges. In many weevils the true mandibles are provided with false mandibles for this purpose, which drop off and leave a scar, after they have been used. In the Sawfly *Athalia proxima*, the imago cuts a lid in the end of the tough cocoon with its jaws and then emerges. Most *Aculeate Hymenoptera* do the same, the thin cocoon being bitten through, and this occurs even in *Megachile*, where masonry has to be pierced.

We have skirted round this fascinating subject in a superficial manner, but we may have said sufficient to indicate that there is here great scope for observation. There are probably abundant devices as yet unknown, and we do not pretend to have even indicated all that are known, but there is very little on record for Indian forms.

BOMBYCIDÆ.

Proboscis and frenulum absent. Forewing, vein 5 nearer 6 than 4. Hindwing vein 1c. absent, vein 8 remote from 7, connected to or approximating to the cell.

This family includes only fifteen species of small dull moths known by the bipectinate antennæ of both sexes and the hairy spurless legs. The proboscis is absent, the antennæ are bipectinate in both sexes, the legs hairy and without spurs. The larva is elongate, with dorsal humps or a terminal horn and is not hairy. A cocoon of silk is formed.

Of the fifteen species listed in the Fauna of India, one alone is found in the plains. *Ocinara varians*, Wlk., is a small grey moth, whose larva lives upon the Gular tree (*Ficus glomerata*) and other figs. It is a grey caterpillar, variegated with brown; there are slight protuberances dorsally and a slender horn at the hind end. It feeds upon the leaves, readily letting itself down from leaf to leaf on a thread of silk; the cocoon is bright yellow, formed on the bark or on a leaf. This insect defoliates its foodplant, stripping large trees of their foliage. It is abundant in the hot weather before the rains and in some years is exceedingly destructive to the large trees upon which it feeds. It is checked by Tachinid parasites.

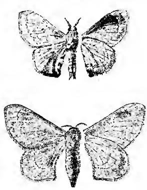

Fig. 327—Ocinara varians. × 2. Male above.

Bombyx mori, Linn. (Plate XXVIII, figs. 9 and 15) is the Chinese domesticated silkworm spread from China to India and Europe. Its domestication dates too far back to be recorded. As a result of domestication in various climates local races have arisen treated by some authors as distinct species. To the student of the Heterocera as a whole, these races will appear as varieties only; to the student of silk insects they are of sufficient distinctness to rank as species, but for our purposes they are domesticated races solely. For convenience we give the more important Indian races described by Hutton as distinct species, united by Hampson under this one species :—

	Bombyx	*mori*, L.	Univoltine.
Desi Polo, Chota Polo.	„	*fortunatus*, Hutt.	Multivoltine.
Nistry, Madrassi.	„	*croesi*, Hutt.	Multivoltine.
Nya Paw.	„	*arracanensis*, Hutt.	Multivoltine.

Boro Polo, Bara Pat.	*Bombyx textor*, Hutt	Univoltine.
Sina, Cheena, Chota Pat.	„ *sinensis*, Hutt.	Multivoltine.

One important difference induced by domestication is the variation in the number of broods ; this is a matter depending largely upon climate, the one-brooded (univoltine) being probably the normal habit in a cold climate with short summer, the multivoltine found in warm moist localities. There is a vast literature upon this subject and every aspect of this insect and its attendant industry has been fully discussed elsewhere (see below, page 489). 'Silkworm gut' is the fibre used by anglers for attaching their hooks, which must be strong and resistant to water ; it is the dried silk of the silkworm extracted by dissection from the silk-glands of the caterpillars just before it commences to spin, and drawn out into a thread from one to three feet long. It consists of the same material as silk, only drawn into a short thick thread instead of into the extremely fine long thread of silk formed by the insect. It is an article of commerce produced in Italy and Japan.

Silkworms also yield an oil (derived from the chrysalides) which is extracted from the stifled chrysalides after reeling. It appears to have little commercial value.

SILK.

The silk of commerce is the thread employed by certain species of insects of the families *Saturniidæ* and *Bombycidæ* (and in Mauritius a *Lasiocampid*) for the formation of their cocoons. There is an immense literature on the silk insects of India and we are not concerned here with the commercial aspect of this question (See Watt's Dictionary of Economic Products, Vol. VI, Pt. III). Using the term in the wider sense to denote the thread produced by insects for cocoon-making or other purposes, we find that the faculty of silk-production is not confined to the few economically important species but is general among a very large section of the insect world.

As a rule, silk is formed in the body of the insect as a fluid in the salivary glands which open by two minute apertures on the apex of the lower lip ; the salivary glands are long sac-like structures with walls composed of large cells, and ending in two fine ducts which lead to the lower lip. Silk is poured out as a thick gummy fluid usually transparent, which rapidly hardens and dries, assuming then a tint of buff, yellow or brown. When used in cocoon-making, the insect spins a continuous thread at first on the object to which the cocoon is fixed, later building up the cocoon of continually added threads. The outer layer is somewhat irregular and not necessarily continuous, as it has to be adapted to the nature of the support, but the inner layer is often formed of practically one thread, disposed regularly round and round and finally ending at some point inside the cocoon where the caterpillar finishes. The cocoon is thus built up from inside, the outside layer first, the fine inner layer last. In many insects this is then cemented with material produced by the caterpillar from the alimentary canal and the cocoon is finished. In some, the production of silk is not continuous, the caterpillar probably resting, and the cocoon consists of distinct layers which may be separated; this is the case, for instance, in Eri and is the reason why a distinct thread cannot be got from these cocoons.

This is the principal use of silk in the insect world, for the preparation of the cocoon to shelter the pupa; the cocoon may not be of pure silk but may include fragments of plants, leaves, etc., or as well as earth or other matter; the hair of the larva is in many used with the silk and forms a large part of the cocoon. Silk is also produced by glands opening on other parts of the body than the lower lip and then differs little from the gummy matter produced, for instance, by some weevils for the preparation of the cocoon (*c. f. Cionus*, *Curculionidæ*).

Silk is not known to be produced by any member of the order *Orthoptera*. The *Embiidæ* produce very delicate silk from glands situate in the forefeet; with this they prepare small web-like shelters on the soil under which they live. The *Psocidæ* prepare somewhat similar webs on the bark of trees or on old wood, the silk being excreted from the mouth-parts in the usual way and being of a very fine nature. The *Myrmeleonides* and *Hemerobiides* among the *Hemerobiidæ* produce silk cocoons; in the former the silk is the product of anal glands and issues from a single spinneret at the apex of the abdomen; the cocoon is white and hard, the pupa being provided with jaws for cutting through and emerging. In the Hemerobiides the cocoon is round and white or is very flimsy and partly formed of a leaf.

Among the *Phryganeidæ* silk is in constant use for the preparation of the cases in which the larva lives and is the product of the salivary glands; some species (*Hydropsyche*) use the silk also in the preparation of the nets which are used to catch their prey. The use and production of silk in this group is similar to that in Lepidoptera. Throughout the *Hymenoptera* silk is produced by the larva for the cocoon; these cocoons are of very varied form, but are almost universally formed of very close fine silk. No cocoon is formed by some of the parasitic forms which pupate in the skin of the host. Among *Formicidæ* the silk is sometimes employed for nest building; this is especially the case with the common red tree Ant (*Œcophylla smaragdina*) an account of which is given on page 232.

Among *Coleoptera* true silk is not formed, cocoons being made of cement produced by the alimentary canal; in at least one species of Chrysomelid, however (*Oides bipunctatus*), this secretion takes the form of coarse threads spun over the pupa and forming a very rough cocoon of thick silk. The bruchid *Caryborus gonagra* prepares a cocoon of coarse gummy threads that almost come within our definition of silk but which are also very little removed from the typical gummy secretion of other *Coleoptera*.

The production of silk as described above is general throughout the *Hesperiidæ* and all *Heterocera* during larval life. In many Micro-Lepidoptera, the silk is of vital importance in larval life, being used to fasten together the habitations of leaves or other matter. So also in *Hesperiidæ* and ***Psychidæ***. In other groups the larvæ use silk in very early life only (*e.g.*, *Caradrina* and other *Noctuids*) or use it to let themselves down from leaf to leaf; practically all can use it to make a rough surface to walk on if they are placed on too smooth a surface; and finally, nearly all use it in the preparation of the cocoon or of the covering of leaves, etc., which shelters them during the pupal period.

Among *Diptera* silk is produced in the normal manner by the larva of *Simulium*, which lives in hill streams and fastens a network of threads across, along which it moves; some other Diptera which live in soil under bark, etc., also prepare silken shelters.

Coccidæ are the last family in which silk can be said to be formed, and this silk is the product of the numerous glands on the *pygidium*; the scale of the *Diaspinæ* is formed of felted threads of silk produced from these glands with the cast skins of the previous instars. In this family as in *Aleurodidæ* the glands producing waxy thread-like excretions are very abundant and can, strictly speaking, be hardly called silk glands; in the Diaspinæ alone is the secretion used as silk is.

*The composition of silk.**—The main constituents of silk fibre are *fibroin* coated with a glue-like substance called *Sericin* or Silk-Albumen, and coloured with ceraceous matter. Lombardy silk (*Bombyx mori*) yields about 70% fibroin and 30% sericin and even technically purified silk contains about 5% glue. *Fibroin* is insoluble in superheated water, in dilute acids or alkalies; it can be heated to 120° C. for hours without any change taking place.

Sericin is soluble in weak alkaline solutions and in hot water, from which it can be precipitated as a white powder by alcohol. The yellow colouring matter of raw silk consists of chlorophyll (the green colouring matter of plants) more or less altered and deprived of its blue constituent. From the cocoon unaltered chlorophyll may be extracted.

Fibroin is obtained by exhausting the silk with boiling water, alcohol (to dissolve and precipitate sericin), ether and acetic acid successively; analysis shows a very high nitrogen and a very low carbon content. It differs in its constitution very considerably from other albumins, as it contains more than 36% Glycocoll, 10% of tyrosin and only a small amount of leucin. Glutaminic and Aspartic acids are absent, and the base radicles are slight in amount. It gives the biuret and Millon's reactions, is not attacked by either pepsin or trypsin, while by strong acids or alkalies it is converted into albumoses or albuminates. The silk coverings of wasp cells and spider's webs give the reactions and show the solubilities of fibroin (Engel and Schlossberger).

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* Kindly prepared by J. H. Barnes, Esq., Agricultural Chemist, Punjab.

Sericin resembles ordinary gelatin in its solubility, but does not gelatinise so readily and is precipitated by acids. The presence of glycocoll is doubtful, while tyrosin and serin are abundant.

PERCENTAGE COMPOSITION.

	Gelatine.	*Sericin.*	*Fibroin.*
Glycocoll (Amino-Acetic acid).	16·5	0·1-0·2	36·0
Alanin (Amino-propionic acid).	0·8	5·0	21·0
Leucin (isobutyl-α-amino-acetic acid).	2·1	present	1·5
Phenylalanin.	0·4		1·5
Prolin (α-Pyrrolidin-carboxylic acid).	5·2		0·3
Glutaminic acid, (α-Amino-normal glutaric acid).	14·0		
Aspartic acid (Amino-succinic acid).	0·56		
Serin (α-Amino-β-hydroxy-propionic acid).	present	6·6	1·6
Hydroxy-pyrrolidin carboxylic acid ($C_5 H_9 NO_3$).	3·0		
Lysin (ε diamino-normal-caproic acid).	5·5	present.	present.
Histidin. ($C_6 H_9 N_3 O$.)	·4		present.
Arginin (Guanidin-α-amino-valerianic acid).	9·3	4·0	1·0
Ammonia.	·43	1·87	
Tyrosin (phenyl-α-hydroxy-α-amino propionic-acid).		5·0	10·0

The weight of silk produced.—In the cocoon the relative weight of silk formed is shown from the following figures of three Eri cocoons (*Attacus ricini*).

Full-grown larva.	126.	grains.	91·6	101.
Cocoon, etc., at emergence.	47·4	,,	36·8	38·8.
,, ,, after ,,	8·2	,,	6·8	6·0.
Pupa case, etc.	1·1	,,	·8	·9.
Cocoon.	7·1	,,	5·8	4·9.

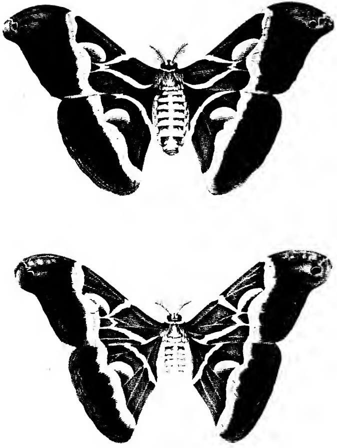
It has been found that in Eri silk 75 to 90 pounds of leaf must be fed to worms to produce a pound of silk.

The following are the more important characteristics of the four commercial Indian silks :—

PLATE XLIV.—ATTACUS [illegible]

ERI SILK MOTH.

Fig. 1. Female above.
„ 2. Male below. (The antennæ are shown too small.)



ATTACUS RICINI.

Bombyx mori : Mulberry Silk :

Univoltine Italian races or Multivoltine Indigenous races; mulberry the exclusive foodplant used; wholly domesticated, never free-living, silk white or yellow, reelable, the pupa requiring to be stifled. Grown in Bengal and Eastern Bengal as in parts of the Punjab, Baluchistan, and in Kashmir for export or local use.

Antheræa paphia : Tasar.

Univoltine or bivoltine, polyphagous on wild forest trees; never domesticated, but fertilisation takes place in captivity from reared females; found wholly free-living in forests. Silk dirty-brown, reelable, cocoon with a peduncle, pupa requiring to be stifled. Collected in the forests of Bombay, Madras, Central Provinces, Bengal, United Provinces and the Punjab for local use and for export.

Attacus ricini : Eri.

Multivoltine, polyphagous but reared only on castor; partly or wholly domesticated for rearing but also found wild rarely; silk white or brick-red, not reelable, the moth being often allowed to emerge from the cocoon before it is used; cultivated in Eastern Bengal and Assam mainly for local use, but also for export for spinning with the waste of mulberry and other reeled silks.

Antheræa Assama : Muga.

Multivoltine polyphagous on wild forest trees; partly domesticated but also found wild; silk white or yellow, reelable, the pupa requiring to be stifled; cultivated in Eastern Bengal and Assam, mainly for local use.

Literature.—There is an extensive literature on Indian silk and sericulture: with the exception of Cotes' papers in Indian Museum Notes, little has been written by persons acquainted with entomology but much is valuable from other points of view; Watt's Dictionary of Economic Products summarises the literature down to 1893, since then the principal papers published are :—

Monograph of Silk Fabric Industry in Madras (E. Thurston, 1899).
Monograph upon the Silk Fabrics, Bombay (S. M. Edwardes, 1900).
Monograph upon the Silk Fabrics, Bengal (N. G. Mukherji, 1903).
Monograph upon the Silk Fabrics, Assam (B. C. Allen, 1899).
Monograph upon Silk in Burma (J. P. Hardiman, 1901).
Monograph on Silk Fabrics in North-West Provinces and Oudh (A. Yusuf Ali, 1900).

Monograph on Silk Industry of the Punjab (W. M. Hailey, 1899).

Report on an Inquiry into Tasar Silk Industry in Bengal and the Central Provinces (N. G. Mukherji, 1905).

BRAHMÆIDÆ.

Frenulum absent: forewing, vein 5, nearer 6 than 4. Hindwing, vein 8, approximated to or anastomosing with 7, 1c. absent.

A family containing a single genus of two species in India, confined to the Himalayas and Burma.

Brahmæa wallichii, Gray, and *B. hearseyi*, Wh., are large olive brown moths of an expanse of 5 to 7 inches, the wings with many black marks. They are not found in the plains and are characteristic of the hill forest areas.

URANIIDÆ.

Forewing with vein 7, remote from 8 and 9, usually stalked with 6; 5 nearer 6 than 4. Hindwing with vein 8 diverging from 7 at the base, vein 1c. absent.

A family of moths almost wholly confined to the Himalayan and other hill regions. In the Fauna of India, Moths, Vol. III, 59 species are described, and Hampson has added 24 species since. It includes the insects described in the Fauna of India under *Uraniidæ*, *Epicopiidæ*, *Epiplemidæ*: of the first, none are plains species and none will be found outside the hills.

Epicopiidæ.—These are moths resembling Papilionid butterflies in appearance and form. This family consists of a single genus and five species, wholly confined to the Indo-Malayan region, Japan and China. The moths are large, coloured in black with red and yellow markings; the forewings are black, the costal margin long; the hindwings are long, narrow and of the form typical of certain Papilios marked with yellow blotches and red marginal spots. The body is narrow, coloured in red and black. The caterpillars so far as known are clothed in white efflorescence which may be in the form of a dense filamentous coat or of a powdery covering. They live on trees and pupate in a light cocoon.

Two forms of the species *Epicopia philenora*, Westw., occur in Bengal, the remaining species and forms in the Himalayas, Malay Peninsula, China and Japan. The most recent account of the family is in *Genera Insectorum* by A. Janet and P. Wytsmann. Of the *Epipleminæ* a small dull brown moth *Dirades theclata*, Guen., alone occurs in our area, appearing during the rains. Its life-history appears to be wholly unknown.

PSYCHIDÆ.

Female wingless in a case; larva of both sexes in a case. Frenulum present in male; forewing with vein 1c. present; proboscis absent; middle spurs of hind tibiæ small or absent. Hindwing with vein 8 connected to cell by a bar or free; 1c. present

The insects composing this family are immediately recognisable from the fact that the female in all stages, and the male except in the imago stage live in cases composed of vegetable matter and silk, the case having a characteristic form for each species. Case bearing larvæ occur

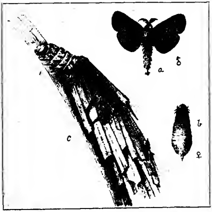


Fig. 328—MAHASENA GRAMINIVORA. A. MALE, B. FEMALE, C. LARVA. [I. M. N.]

also in other groups, *e.g.*, *Tinea* in houses, Coleoptera, etc., on plants, but they are far smaller.

The males are small delicate moths with dusky or hyaline wings and markedly pectinate antennæ. They are very rarely seen and come out after dusk. The female is an undeveloped chrysalis-like insect without wings, which remains in the larval case.

The life-history of the known species is as follows: The female is fertilised by the male in the case, the long protrusible abdomen of the male penetrating into the female case from above. Eggs are laid in the case, the female gradually shrinking up as the eggs fill the lower portion of the case. The larvæ hatch, emerge from the parents' case and make their own little cases of vegetable matter and interwoven silk; these cases are extremely tough and durable, with a characteristic form and constitution for each species. Pieces of leaf, thorns, leaf-stalks or finely divided vegetable matter are woven into the case which is open at each end, the head and thorax of the larva emerging at one end; progression is effected by the thoracic legs, the case being firmly held by the hind end of the body. This larva is a typical caterpillar with three pairs of legs and can extrude the thorax for purpose of locomotion, dragging itself and its case slowly along; when full-grown the male larva closes the case after firmly fastening it, the caterpillar pupates head downwards, the pupa wriggles half through the lower open end and a moth emerges. The female larva moults, passes through a period of rest, and is found in the case as a vermiform sac, without external structures and simply a bag of eggs with a genital opening below. The male seeks out the female, fertilises her by introducing his protrusible abdomen at the upper end of the case and stretching it to the lower end and she subsequently lays her eggs in a mass in the lower part of the case. Parthenogenesis occurs in one species, but is not known in any Indian species.

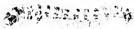
Hampson lists 35 species, and has added five since, almost all from Ceylon or the hills. Actually very little is known of the group, as the moths are rarely captured and it is not always possible to rear the larvæ. Species can, of course, be distinguished only from the male moth. No species is really common, but several species are likely to be found, as larvæ, in the plains. The life-history is a slow one, and to breed the males requires much patience, but it is the only satisfactory method.

PLATE XLV.—ARBELA TETRAONIS.

Fig. 1 } Larva, full grown.
,, 2. }
,, 3. Second and third abdominal segments of larva.
,, 4. Pupa.
,, 5. Ventral surface of pupa. x 6.
,, 6. Apex of abdomen of pupa. x 6.
,, 7. Moth.
,, 8. Branch showing the masses of excrement and webbing with which it covers the bark on which it feeds.

PLATE XLV.

1



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***Mahasena** graminivora* Hampson is figured here in all stages: it is found in rice in the plains, its case being formed of rice leaves sewn together with silk. The figures are taken from specimens reared in Calcutta on thatching grass. (Indian Museum Notes, IV, p. 19.) We figure also the case of *Psyche vitrea*, Hmpsn., which feeds upon mango leaves in the plains of India. The moth has entirely hyaline wings. Most species have dark wings and are distinguishable on the venation which is very distinct, and on the nature of the larval case; no species can be considered as real pests, though a number are recorded upon tea in the hills and the last mentioned species has been found destructive to mango. We may also mention *Acanthopsyche moorei*, Heyl., found in Calcutta on *Lagerstrœmia indica*. described as *Babula grotei* by Moore. A short account of this insect occurs in Indian Museum Notes, II, p. 13. The larvæ of *Chalia Doubledayi* feeds on Amaltas (*Cassia fistula*) which they disfigure by eating the epidermis: specimens were sent in as being very destructive to this tree and killing it, being very abundant.

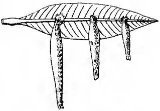


Fig. 329—PSYCHE VITREA CASES ON LEAF.

ARBELIDÆ.

Forewing, vein 1c. absent. Hindwing, vein 8 free or connected to the cell by a bar, vein 1c. present.

A small family of moths in which the proboscis is absent, and the male antennæ are bipectinate to the apex with short branches. A single genus *Arbela* (5 species) occurs in India in the form of the familiar borer of lichi, bair, guava, mango, orange and other fruit trees. The larva may be known by the peculiar patches of excrement and silk found on the bark of these trees near the bore of the caterpillar, which comes out at night, feeds on the bark and makes this peculiar covering on the part it eats. The insect is a very common one in the plains, the species being *A. **tetraonis***, Mo., figured here in all stages. (Plate XLV.)

Antram has described the life-history of *A. dea*, Swinh., and *A. quadrinotata*, Wlk., which eat the bark of tea in Assam. (Bull. Tea Association, 1907. No. 5.)

RATARDIDÆ.

Frenulum absent; forewing, vein 1c. *present; proboscis absent; middle spurs of hind tibiæ short or absent. Hindwing, vein* 8 *free or connected to cell by a bar, vein* 1c. *present.*

The family contains a single genus *Ratarda*, of moths formerly classed with *Lymantriidæ* and consists of a single species, *R. marmorata*, Mo., described from Sikkim.

COSSIDÆ.

Both sexes winged. Frenulum present, proboscis absent, middle spurs of hind tibiæ short or absent; forewing, vein 1c. *present, hindwing, vein* 8 *free or connected to cell by a bar, remote from* 7, *vein* 1c. *present. Larva boring, pupa in bore.*

These are medium-sized to large moths, with long narrow wings and a long abdomen, usually coloured in grey, brown or dull colours. The antennæ are bipectinate in the males or in both sexes, the males being usually conspicuously smaller than the females. The larvæ are found

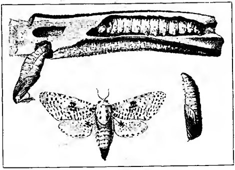


Fig. 330—ZEUZERA COFFEÆ. [I. M. N.]

boring in trees, eating large tunnels through the wood. They are smooth with five pairs of suckerfeet, the body usually with chitinous dorsal plates. Some emit a characteristic and unpleasant odour. Pupation takes place in the tunnel, the pupa not in a cocoon ; a hole is previously made to the outside and the pupa before emergence wriggles partly out of the bore, the moth then escaping readily. The moths are nocturnal in habit. Practically all are hill forest species and only rarely found in the plains. Hampson lists twenty-three species as "Indian."

Cossus cadambæ, Mo., is a brown insect whose larva is recorded as boring in teak in Travancore. (Ind. Mus. Notes, I, p. 198.) *Duomitus leuconotus*, Wlk., is a large black and white moth with an expanse of 4 to 5 inches in the male and 7 inches in the female. This insect occurs scattered over India, usually near or in forest areas. *D. mineus*, Cram.,

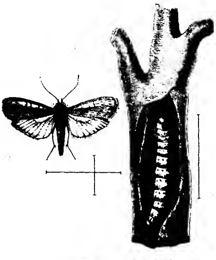


Fig. 331—COSSUS CADAMBÆ. [I. M. N.]

is smaller, coloured in metallic blue and yellow, also widely scattered but not common.

Azygophleps scalaris, Fabr., and *A. pusilla*, Wlk., are found rarely. The former is found boring in *Sesbania grandiflora* (*agathi*) and *S. ægyptiaca* (Jainti) in Bengal and Madras. The moth lays a large mass of eggs, numbering from 500 to 2,000, between and on the leaflets, cemented firmly together. The caterpillars on hatching let themselves down by threads and are blown from plant to plant and so secure a wide distribution among the thickly growing plants. A single caterpillar tunnels from the growing points down the main stem, biting holes to the air at intervals. Larval life lasts from 7 to 12 weeks, the full grown caterpillar being white, nearly three inches long. Pupation takes place in the tunnel behind silken partitions, and the moth emerges from the pupa after it has pushed its way through these and through the thin epidermis of the bark which alone is left intact.

Zeuzera includes the red Borer of the coffee plant, *Z. coffeæ*, Nietn.; the reddish caterpillar tunnels in the stems of the coffee bush and is often destructive; it is also found in Sandal (*Santalum album*); a considerable amount of attention has been paid to this insect and the interested reader may consult Bidie, the Ravages of the Borer (Madras, 1869).

LASIOCAMPIDÆ.

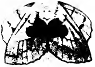
Frenulum absent, hindwing with vein 1a. reaching the tornus, no precostal spur to vein 8, which is curved and approximated to or connected with 7, or anastomoses with it. Forewing with vein 5 nearer 4 than 6; hindwing with vein 1c. absent. Larva with downwardly directed tufts of hair, pupa in cocoon of silk and hair.

The moths cannot be recognised on superficial characters in the field; most are of moderate size, thick bodied, of light colour, cryptic in design. Their resemblance when in the resting attitude to a leaf is sometimes very marked and beautiful. The antennæ are short and bipectinate, the palpi small and porrect. The legs are hairy with minute spurs, the females usually with an anal tuft of hair. Males and females differ in little but size, colour and the extent of pectination of the antennæ. The life-history is known in some species; the eggs are laid in irregular clusters and covered in hair; the larvæ are hairy without upright tufts but with

PLATE XLVI.—TRABALA VISHNU.

CASTOR HAIRY CATERPILLAR.

Fig. 1. Eggs.
,, 2. Newly hatched larva.
,, 3. Half-grown ,,
,, 4. Full-grown ,,
,, 5. Cocoon.
,, 6. } Pupa.
,, 7. }
,, 8. Male, resting attitude.
,, 9. Female, ,,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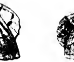
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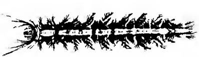
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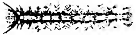
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long tufts projecting in front and short tufts laterally. They are all herbivorous and sometimes destructive. Pupation takes place in a cocoon of mingled silk and hair, usually on the soil among leaves, etc. So far as known, hibernation takes place in the pupa stage and the insects breed freely in the rains.

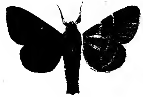


Fig. 332—METANASTRIA HYRTACA. MALE.

Over fifty Indian species are listed by Hampson of which about six are to be found commonly in the plains. *Taragama siva*, Lef. (Plate XLI, figs. 8-11), is a handsome moth, whose larva feeds on rose, on bér (*Zizyphus jujuba*) and babul (*Acacia arabica*); it is greyish brown with tufts of long hair, on the thorax are tufts of short dense hair which open to display a band of orange and bright blue hair. The cocoon is formed on a twig of the plant. *Suana concolor*, Wlk., is recorded as feeding on Sal (*Shorea robusta*).

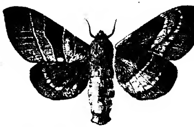


Fig. 333—METANASTRIA HYRTACA. FEMALE.

The larva of *Metanastria hyrtaca*, Cram., was found by Forsayeth (Trans. Ent. Soc., London, 1884, p. 407) to feed upon the mohwa tree (*Bassia latifolia*). It has been reared from *Albizzia stipulata*. The grey larva is clothed in black hairs, with a velvety black patch on the mesonotum, which is concealed by the skin except when the larva stretches out.

Trabala vishnu, Lef., is a widespread insect, the grey larva feeding upon Castor, Jam (*Eugenia jambolana*). Sal and the country almond (*Terminalia catappa*). De Nicéville reared this with many others on the last in Calcutta (Ind. Mus. Notes, V, p. 107). The moths are large, the female larger than the male; at rest the costal edge of the lower wing projects in front of the upper wing and there is a very close resemblance to a leaf; the female is yellow, the male a delicate green. (Plate XLVI.)

Estigena pardalis, Wlk., is a brown moth, with a very close resemblance when at rest to a brown leaf, the projecting palpi forming the black twig, the head forewings and projecting costal part of the forewing presenting an even surface entirely concolourous with no projecting edge and looking like a leaf. The antennæ are hidden and the whole resemblance is extraordinarily close. (Plate XLI, fig. 12.) The larva is a long grey larva, with the typical lateral tufts and on the thorax short tufts of dense black hair. It is found in the early rains and the moth is crepuscular.

LIMACODIDÆ.

Frenulum present; hindwing with vein 8 anastomosing with cell, distinct from 7 : vein 1c. present.

The common members of this family have a characteristic facies, with a rounded forewing and a somewhat short and rounded hindwing. The palpi are short, porrect or upturned, the antennæ commonly pectinate in the male, the body rather thickset and short. Most are dull coloured in shades of dull brown, but some are more or less coloured in bright green.

The most characteristic features of the family are found in the immature stages. Eggs, so far as known, are flat and scale-like, laid in overlapping rows. The larva is slug-like, the head, legs and suckerfeet retractile, the ventral surface forming a peculiar smooth sucker-like attachment along which the larva glides as a slug does. There are three forms of larva; in one, the body is distinctly segmented above and bears spinous tubercles, the spines often very irritant owing to the presence of formic acid (*Natada, Thosea, Parasa, Narosa*, etc.); in another, the body is segmented but without tubercles (*Cania, Altha*, etc.); in the third, the body is covered above in a thick smooth skin without visible segmentation (*Belippa*, etc.). The last includes the so-called "Gelatine grubs," smooth gelatinous insects of a dull green colour found in very moist localities in the hills. (Plate XXVIII, fig. 14.) The commoner plains' species are of the first type.

Pupation takes place in a very hard round or oval cocoon, which opens at one end in a distinct lid for the emergence of the imago. The pupal period is commonly long and this compact cocoon is a protection during the period of hibernation. None are definite pests in the plains since they occur only rarely: *Belippa* has been found to injure Cinchona in the Himalayas. Hampson lists 25 genera with nearly one hundred species of which less than ten occur within our limits; 24 species have been added since the Fauna volume was issued.

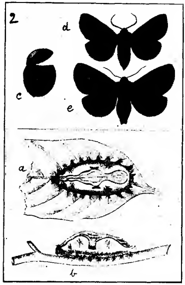


Fig. 334—THOSEA CERVINA. A. B. LARVA, C. COCOON, OPEN. D. MALE, E. FEMALE (I. M. N.)

Altha nivea, Wlk., has been reared from larvæ found upon castor leaves and is, though rare, widespread on this plant in the plains. The white moth is singularly beautiful, the thorax heavily tufted with upright scales.

Thosea cana, Wlk., is a dull brown moth, whose green larva feeds on castor. The larva has a double row of tubercles bearing spines.

The larva of *T. tripartita*, Mo., has a dorsal and a lateral series of blue spots and was found by Forsayeth to feed on the Palas tree. (T. E. S. London, 1884, p. 14.) We figure the larva of *Natada velutina*, Koll., which feeds on mango and has extremely irritant spines. The moth is red-brown with an expanse of three inches. *Miresa albipuncta*, Herr.—Schaff. has a silvery spot on the forewing; its larva was found by Forsayeth on the Palas tree (*Butea frondosa*).

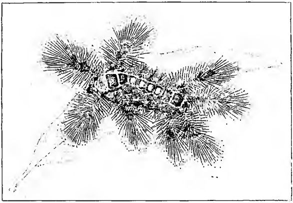


Fig. 335—NATADA VELUTINA, LARVA. (I. M. N.)

Three species of *Parasa* are common and likely to be found; all have green occupying the middle of the wing, with more or less brown on the body and wings. The larva of *Parasa lepida*, Cram., feeds on castor and mango; it is also recorded as having been very abundant on Asphal (*Nephelium longana*) in Calcutta (I. M. N., IV, p. 21), and de Nicéville reared it on the country almond

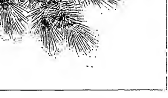


Fig. 336—PARASA LEPIDA LARVA.

(*Terminalia catappa*). It pupates in very compact felted cocoons on the trunks of trees in which state it is often found abundantly. We figure the larva of *Belippa laleana*, Mo (Plate XXVIII, fig. 14), a gelatine grub, in which the outlines of the segments are lost, and the dorsum consists of a smooth semi-transparent mass of tough tissue; the beautiful tufted red-brown moth is found in the plains rarely.

NEOCASTNIIDÆ.

No proboscis; hindwing with vein 8 free, remote from 7, frenulum present, i.e. absent, forewing with vein 5 nearer 4 than 6.

A single moth, found in Tenasserim, is the sole Indian representative of the family. *Neocastnia nicevillei*, Hampson, is described in Trans. Ent. Soc., Lond., 1895, p. 285, as also in Fauna of India, Moths, Vol. IV, p. 471.

MICROLEPIDOPTERA.

The characters of the group are defined above on page 432, and we have there stated our reasons for adopting this grouping. Apart from the purely structural characters of the group as shown by the venation of the wings of the imago, there are other characters which make the group at least a useful one in practice if not also a logically correct one phylogenetically. The eggs of these moths are, as far as known, different in character from those of the Rhopalocera, and from the majority of the Heterocera: they are flattened, often scale-like or elongated, with the micropile at one end; they are not ornamented with radial ridges and polar points but are often reticulate or simply smooth. The larva has the five pairs of prolegs equally developed as a rule, the hooks on them being in a circle and not set in two opposed lines; they are smooth cylindrical larvæ with few short hairs and of the form known generally as "Pyrali-form." They live commonly in concealment (except *Pterophoridæ*) and do not feed openly; where they are leaf eaters, they roll the leaf or hide themselves with it or in it in some manner; many are borers in soft tissues, and if we exclude the large borers in woody tissues, the majority of the agriculturally important boring caterpillars are included here.

Periods of rest are commonly passed in a resting larval condition and not in the pupal condition as in the larger moths: pupation takes place in concealment in a covering of leaves, bark or other material with a small quantity of silk as a rule, though one family (*Pterophoridæ*) pupate openly without a cocoon and another (*Zygænidæ*) make a silk cocoon in the open.

The imago is in the majority of cases small in size and the group includes almost all the small moths found in the plains; but size in itself is no criterion in this case, and the characters enumerated here are supported by the structural distinctions given above.

ZYGÆNIDÆ.

Hindwing vein 8 connected to cell by a bar and approximated to it; vein 1c. present. Proboscis present (except Phaudinæ); middle spurs of hind tibiæ very short or absent.

A small family of moths, believed to have been derived from the *Tineidæ*, embracing insects of very divergent appearance. The *Zygæninæ* are small moths, resembling the *Syntomidæ*; the *Chalcosiinæ* are large, the antennæ bipectinate to the tips, often with a resemblance to butterflies; the *Phaudinæ* are smaller, without mouthparts, and including but few genera. The most interesting feature of these moths is the very marked Batesian mimicry that some of the species exhibit, mimicking protected butterflies; the figures illustrate this for one species but it occurs in several, and the moth collector in the hills where these moths occur will be forcibly struck by their resemblance to insects widely removed from them in ancestry.

So far as known the species are almost wholly hill or forest forms, not occurring in the plains. *Tasema fuliginosa*, Mo., is a small moth, dark brown and black, with an expanse of 15—17 m.m. found in Calcutta; *Lophosoma quadricolor*, Wlk., is slightly larger, brown shot with green, the abdomen cupreous and purple, with lateral tufts of hair on the apex, found in Bengal and Ganjam. *Campylotes histrionicus*, Westw., is a very vivid hill species, which on being handled, emits a bubbling frothy liquid from apertures on the side of the head, as does the grasshopper, *Aularches miliaris*, this being protective in conjunction with the warning colouration. *Thyrassia subcordata*, Wlk., resembles a *Syntomid*, the forewing brown with hyaline spots, the hindwing orange and brown, with an expanse of one inch. We figure *Isbarta imitans*, Butl., with the butterfly

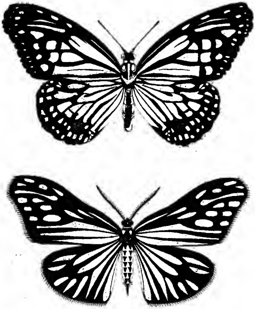


Fig. 337—DANAIS AGLEA (ABOVE) AND ISBARTA IMITANS. REDUCED ½.

it mimics, *Danais aglea*. *Trypanophora semihyalina*, Koll., is figured in Indian Museum Notes, Vol. V, pl. X, from specimens reared by de Nicéville on desi badam (*Terminalia catappa*) in Calcutta. The species of *Heterusia* feed upon tea in subtropical India and Ceylon; an account will be found in Bulletins, Indian Tea Association, 1906, No. 5, and Journ. Bombay Nat. Hist. Soc., XVIII, p. 130.

CALLIDULIDÆ.

A precostal spur to vein 8 of hindwing which is curved and approximated, or anastomosing with, or connected to 7 by a bar. Vein 1c. absent. Forewing vein 5 nearer 4 than 6.

These are day-flying moths of medium size with simple antennæ and long palpi; six species are known from the hills, none in the plains.

DREPANIDÆ.

Hindwing, vein 1a absent or reduced, no precostal spur to vein 8, which is curved and anastomoses with, or approximated to, 7, or is connected by a bar; vein 1c. absent. Forewing vein 5 nearer 4 than 6.

These are small moths of slender build with the wing apex often produced; the wings are large, the palpi slender and the antennæ simple or pectinate in the male. Nearly all are hill forms and are not met with in the plains. The larva is bare, the anal prolegs absent, the body ending in a long process and having humps on the segments. The pupa is found in a cocoon among leaves. (Hampson.) The Fauna lists 65 species and 14 have been since added by Warner, Swinhoe and Dudgeon from the Himalayas and Khasis. These moths are found almost wholly in subtropical India, only one being known to breed in the plains, though others are very occasionally captured near forest areas. They are not uncommon in hill forest areas and are one of the families so characteristic of the subtropial zone of insect life in India. *Phalacra vidhisara*, Wlk., is a small reddish-brown moth whose larva feeds on the toddy palm (*Phœnix sylvestris*). It is a broad larva, green with four rows of pink processes bearing spines, lying on four green ridges which are connected by cross ridges; between these are purple spots; the head is retractile. The larva is slow and inactive, feeding on the leaf. This insect occurs rarely in the moister parts of India. *Orcta extensa*, Wlk., is more widely spread, a brilliant yellow moth with the forewing drawn out at the apex.

THYRIDIDÆ.

Frenulum present, hindwing vein 1a reaching tornus, no precostal spur to vein 8, which is curved and approximated to or anastomosed with vein 7 or connected by a bar. Vein 1c. absent, wing vein 5 nearer 4 than 6. Moderate sized moths accurately distinguished by the venation above. The palpi are upturned and slender, the antennæ not pectinate.

A family of nearly 60 species of which three are found widely distributed in India, the remainder known only from a few localities in the hills. The life-histories are little known, the larvæ known having five pairs of prolegs, few hairs and the form common in *Pyralidæ*. *Rhodoneura* is the most important genus, represented by *R. myrsusalis*, Wlk., *R. myrtæa*, Dr., and many hill forms. *Dysodia ignita*, Wlk., is also widespread, the larva boring in wood.

PYRALIDÆ.

Hindwing with vein 8 anastomosing with or approximated to vein 7, vein 1c. present. Slender moths with long thin legs, with labial and maxillary palpi usually well developed, the proboscis present or absent.

A large family of moths of usually moderate to small size, few having an expanse so large as two inches. They are intermediate in size between the robust Noctuids and the minute Tortricids and Tineids; actually the majority of the smaller moths seen in the field are *Pyralids*, but there is no means of definitely ascertaining this save by working out the venation and the student will confuse smaller Noctuids and the large Tineids with Pyralids. The greater number of the smaller moths in grass and at lights are Pyralids and the family is a very extensive one. The colour schemes of these moths are extremely diverse and are not of the more obviously cryptic or warning kind of larger Lepidoptera. To those who study the group in the Museum, the colouring presents a great variety that, subordinated to points of structure, offers reliable specific distinctions. Sexual differences are expressed in the structure of the wings, palpi or antennæ, or in the size but rarely in the colour. To the field naturalist, the colour patterns of many *Pyralidæ* are inexplicable; the grey forms, such as many of the *Galleriinæ*, appear to be vaguely cryptically coloured, or at any rate, inconspicuously coloured. The grass moths are often "dry grass coloured" and equally inconspicuous, but *Scirpophaga*, for instance, is white and very conspicuous by day in its open resting position on a green leaf. Many *Phycitinæ* are grey, or modestly coloured and in their resting attitude blend with the shadows of the cool dark places in which they rest. Of the complex patterns of *Nymphula*, it is possibly near the truth to say that the minute marking blends with their surroundings in a manner we, with grosser sight, cannot appreciate. Of the *Pyraustinæ*, with their variety of tints, no adequate explanation is possible. There is almost every tint of white, to yellow, green, brown, orange and so on, the colour pattern often complex and vivid, often a blending of soft tones with little contrast.

The antennæ are usually simple, the males with ciliations or tufts, with expanded basal joints or with pectinations. The characters of the male antennæ especially are of value in discriminating species. The labial palpi are usually conspicuous, porrect or upturned, of varying length and very diverse form; in some they are large, and densely scaled, concealing the smaller labial palpi that lie above them; the small curled proboscis is not conspicuous and is frequently absent. The thorax and abdomen are typically slender, densely scaled; the latter may be tufted or terminate in a tuft of long scales in the males. The legs are long, with distinct spurs. The wings are usually slender, without long hair fringes, often with tufts of scales in the males; they are in some sub-families wrapped round the body in repose, in others placed one over the other flat on the abdomen as in the Noctuids, rarely held out from the body as in the *Rhopalocera*. Males and females are commonly similar in appearance, the males with ciliations of the antennæ, dilated palpi, or tufts of scales on the wings, legs and abdomen.

The life-history is uniform in general character throughout the group. The eggs are flattened, laid singly or in clusters upon the foodplant and are, as a rule, inconspicuous. A few species are known to cover them with hairs (*Schœnobius*, *Scirpophaga*). The larvæ are, with exceptions, of one general type, cylindrical, tapering evenly to head and tail, the segments distinct; a prothoracic shield is present or absent, the prolegs are ten in number, and there are fine hairs set on flat tubercles, usually dark in colour. Tufts of hair and protuberances do not occur. In general the larvæ live in concealment, either boring in stems or fruits, living below ground amongst decaying leaves or in bark, or rolling leaves as shelters. Some of the *Hydrocampinæ* are aquatic, whilst a few species are household pests or live in bee-hives. A character the larvæ share with the *Tineidæ* is that the suckerfeet have the hooks in a circle, whereas those of the *Noctuidæ* and other *Macrolepidoptera* are in two opposed series on the suckerfeet. The pupa is hidden, in a cocoon or in a shelter. It is commonly chestnut brown with some segments of the abdomen movable. In most known species, the life-history is short, the larva developing rapidly, the period of pupation short in the hot weather or rains. Hibernation or an equivalent period of rest occurs in all but those whose food supply is always available, and this is frequently spent in a resting larval condition as in most microlepidoptera.

In general, this period of rest appears to depend upon climatic conditions and food supply, varying with individual species. A large number appear as larvæ in the rains and until October, when they disappear again. The cold weather is passed in all stages, most generally in the resting larva, rarely the pupa, state. Many emerge as imagines in March or April and breed if food is available, if not, living over until the rains. The question is too big to be adequately discussed here and the simplest general view is that each species breeds when climatic conditions permit of food supply and that in most, this occurs only in the rains and immediately after. The collector will find his specimens most abundant in March, April, June, August and October. Practically all species probably fall roughly into five groups: (1) those that are to be found in their foodplant throughout the year, with a period of hibernation varying with the locality and temperature (*e.g.*, *Chilo simplex*, *Euzophera perticella*, *Scirpophaga*): (2) those that do not hibernate in their foodplant but are found breeding from April to November, hibernating in the soil or in shelter (*e.g.*, *Sylepta*, *Phycita*): (3) those that appear and breed only in the rains (*e.g.*, *Marasmia*, *Pachyzancla*, *Antigastra*): (4) those that appear in the hot weather and hibernate in the rains (*Anerastia*): (5) others, whose development is dependent wholly upon the fruiting of trees, etc., and which are found once, twice or often in the year with periods of waiting between as larva or imago (*Euzophera punicaella*, *Heterographis bengalella*). There are then such household species as *Ephestia*, whose broods are continuous throughout the year, due to abundant food.

Many species are nocturnal, coming out in the dusk to fly actively and to mate. During the day they remain concealed in shady moist places. Some are found resting in exposed situations during the day, the white *Scirpophaga auriflua* being commonly seen on rice or cane leaves and others on bark, on walls, etc. Many are attracted to light and numbers come into houses at night.

The eggs of such *Pyralidæ* as are known, have been found to contain egg parasites of the family *Chalcidæ*. These parasites are an important check upon the destructive species which lay eggs in clusters in the open. The larvæ are attacked by parasitic Hymenoptera and, more rarely, *Tachinidæ*, as are other caterpillars, and every abundant species has its parasites. Predaceous and stinging Hymenoptera also prey upon the larvæ, feeding upon them or laying them up for their young. Carabid larvæ feed upon such species as live exposed and other predaceous insects probably destroy large numbers of the more hidden caterpillars. The moths are preyed upon by dusk and night-flying bats principally.

This family is, with the *Noctuidæ*, the most destructive to crops and stored products. A large number of species feed upon cultivated plants and several upon grain, flour, etc. The destruction is caused wholly in the larval stage, some of the widely spread species being responsible for much loss in Indian Agriculture. Almost all the destructive boring caterpillars fall into this group; the moth-borers of cane, the stem-borers of brinjal, the borers of pulses, castor seeds, til capsules, brinjal fruits, pomegranate fruits, the leaf-rollers of cotton, rice, maize, being the best known examples of injurious species in India

A great deal remains to be learnt of Indian species; two of the common borers of cane in Behar were described only after they had been reared from the caterpillars, and there are many undescribed species to be found in the plains. The life-histories of few are known and these are the species that are most readily found as caterpillars. There are many species that live as larvæ among roots of plants, in grass-stems, in bark, on wild plants, which remain to be worked out. To the student of life-histories there is ample room for work and the systematic collecting and rearing of *Pyralid* caterpillars would yield much that is new and probably throw much light on the bionomics of this group.

The moths are classified upon characters derived from the venation.

the presence and form of the maxillary palpi, the form of the labial palpi. The species are largely distinguished by the male characters, which include tufts of hair on the wings and anal segment, the form of the antennæ, the form of the palpi. For such characters and for the classification of the Indian species, *Hampson's Moths of India*, Vol. IV, should be consulted, but the actual identification of species from such a volume is a matter of very careful study and, until some experience is gained, is not an easy matter. We may add that the family requires very careful study, and revision, and it may be hoped that when more material is available, this will be done. Volume IV of the *Fauna of India* contains descriptions of 1,130 species from India, Burmah and Ceylon and Hampson has since added over 300 species from India (*Journ., Bombay Nat. Hist. Soc.*, XII, XV, XVIII). The student of this group should see Waring and Swinhoe's articles on the *Khasi Species* in *A. N. H.*, Ser. VI, Vols. 16, 17, 18.

Galleriinæ.—A small sub-family distinguished by the venation and filiform maxillary palpi. The known larvæ live in concealment and produce much silk in the form of webbing and cocoons. *Trachylepidia fructicassiella*, Rag., is one of several moths which may be reared from the pods of Amaltas (*Cassia fistula*). The female, which is larger than the male, has far larger palpi. The species is widespread in India, where its foodplant grows; there are probably two broods yearly at least, a distinct one being known in November to March, another in September, but this depends upon the fruiting of the foodplant. *Achroia grisella*, Fabr., is bred from bee-hives, the larva feeding on the wax. *Lamoria, anella*, Schiff., has been bred from larvæ found among fallen leaves of indigo; the larvæ were black at first, becoming sordid white later; pupation took place in a cocoon of silk and leaves, the pupa remaining torpid through the cold weather and only emerging in March as a moth. *Acara morosella*, Wlk., is worth mention, though a hill species, on account of its size, the wings having an expanse of 2 to 3½ inches.

Galleria mellonella, Linn., feeds also in bee-hives; the larva burrows in the wax and produces long tunnels of silk in which it lives; it utilises this silk also for firmly fixing the combs and produces great quantities in a very short time; the moth is larger than that of *Achroia grisella*, the inner area of the forewings in repose forming a flat triangle from which the wings slope on each side; this inner area is ochreous, the outer grey irrorated with purplish and fuscous; the larva is of the typical form and dirty white colour, pupating in a tough cocoon of white silk.

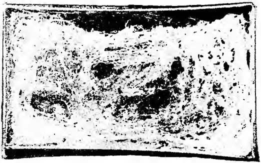


Fig. 338—WEBBING PRODUCED BY LARVÆ OF GALLERIA MELLONELLA.

Stenachroia elongella, Hmpsn., is found abundantly on occasion, the larvæ webbing up the ears of Sorghum (*Andropogon sorghum*) and Marua (*Eleusine coracana*) and destroying grain; they also bore in the stems. The attacked ears become deep purple-black from the excrement entangled in the webbing and the decayed grains. The moth is dry-grass colour with long narrow wings and superficially like the cane-borers of the genus *Chilo*.

Crambinæ. Grass moths.

Moths of moderate or small size, with porrect labial palpi, and triangularly scaled maxillary palpi. The larvæ so far as known, live on or in the stems and roots of grasses. *Crambus* is the large genus embracing many species. *Crambus corticellus*, Hmpsn., is a common brownish moth, found at light. None of the genus seem to have been reared in India, but they will probably be found to have the habits of what are called "Sod Web Worms" in America, *i.e.*, to live in the soil at the roots of grasses, much as *Polyocha saccharella* does.

Chilo simplex, Butl. (Plate XLVII, figs. 1, 4, 15, 16), is a widespread species in India, abundant in cultivated cane, juar, bajra and maize.

The life-history has been fully described in the *Agricultural Journal of India*, Vol. I. p. 97, 1906, and III, p. 104, 1908. This species ranges over the whole of the plains from the extreme north to the extreme south; with it is *Chilo auricilia*, Ddgn., a species described from Behar, and found also in other localities in Bengal and Madras. The character of the male antennæ, the metallic markings on the forewing and the white edges to the marginal black spots distinguish this species, whose life-history is apparently identical with that of *C. simplex*. The genus requires revision.

One of the commonest moths of the plains is a small dry-grass coloured one, with silvery fasciæ and black streaks on the wing, which comes readily to light. This is *Ancylolomia chrysographella*, Zell., whose larva lives in rolled rice and grass leaves. The larva of *A. locupletella*, Koll., is said to bore in the stems of *Spinifex squarrosa*.

Schœnobiinæ.—A small sub-family in which the proboscis is minute or absent, the palpi usually porrect. The larvæ bore in the stems of grasses. *Scirpophaga auriflua*, Zell. (Plate XLVII, figs. 2, 5, 10, 14, 17), with its variety *intacta*, Snell., and *S. monostigma*, Zell., are borers in munj grass (*Saccharum ciliare*), which also attack cultivated sugarcane. The eggs are laid in clusters covered by the hair from the anal tuft of the moth. The larval habits are peculiar, the caterpillar always tunnelling down through the apical bud and when full fed, making cross partitions across the tunnel before pupation. The life-history is described in Indian Insect Pests (p. 130), and Agric. Journ., India, III, No. 2. The different species are readily distinguished. *S. auriflua* is white with a buff anal tuft in the female; its variety *intacta* has the anal tuft red outside; *S. monostigma* has a single black spot on each forewing.

Fig. 339—SCHŒNOBIUS BIPUNCTIFER EGG MASS. × 3.

Schœnobius bipunctifer, Wlk., is a moth of similar appearance, but the female of a dull ochreous yellow colour with a single black spot on each forewing, the male brownish ochreous and smaller. It is a very common insect in the plains and comes readily to light. The eggs are also laid in hair-covered masses. The white larva has been reared from the stems of rice in Bengal and Madras. Probably it breeds also in other grasses as it is often abundant. A full account is being published elsewhere.

Cirrhochrista brizoalis, Wlk., was reared from small greyish caterpillars found under the bark of a forest tree: the full-grown larvæ pupated between two pieces of bark bound together with silk. The moth is white with a fulvous (red-brown) edge to the forewing.

Anerastiinæ.—A small sub-family, distinguished by the venation; the larvæ feed on grass roots below the surface of the soil or bore in grass stems. *Anerastia ablutella*, Zell. (Plate XLVII, figs. 8, 11), was reared from sugarcane by Mr. Mackenzie in Behar; the larva is light green and is active only for a short time in the year, hibernating from May to February (See Agric. Journ. India, III, No. 2).

Polyocha saccharella, Ddgn. (Plate XLVII, figs. 7, 12, 19), was also described from specimens reared by Mr. Mackenzie from cane. The larva is white and bores in the cane below ground (Agric. Journ., India, III, No. 2). *Polyocha cinerella*, Hmpsn., was reared from larvæ boring in the fleshy tissues of Sij. (*Euphorbia neriifolia.*)

Phycitinæ.—The proboscis well developed, the moths commonly with narrow wings, rolled tightly round the body when at rest. With some of the last sub-family these constitute the so-called "Knot horns", the male antennæ being often dilated near the base. The larvæ are often borers in plants.

Ephestia is familiar throughout the world, the larvæ of some being injurious to stored flour and the like. *E. cahiritella*, Zell., and *E. cautella*, Wlk., feed in rice and in wheat flour in India, the larvæ producing abundant silk with which they form galleries of webbing in and on their food. They represent the notorious Mediterranean flour moth, *E. kuhniella*, which is so destructive in America. The larva of *E. cautella*, Wlk., is recorded by Zehntner as feeding on a scale insect (*Ceratovacuna*) in

Java (this may prove to be a distinct species). We have reared it also from tamarind seeds and it probably has a great variety of foods.

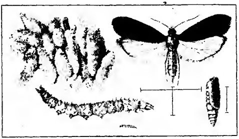


Fig. 340—EPHESTIA CAHIRITELLA.

The custard apple (*Anona squamosa*) fruit is tunnelled by the larva of *Heterographis bengalella*, Rag., and where this fruit is grown, the moth can be readily reared. This pest was described from Calcutta specimens (Ind. Mus. Notes, III, p. 107).

The life-histories of three species of *Euzophera* are known in India. *E. perticella*, Rag. (Plate XLVIII). is a widespread pest of the cultivated

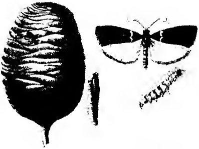


Fig. 341—EUZOPHERA CEDRELLA × 2.

brinjal (*Solanum melongena*) in the plains throughout India, the most destructive of the pests of this crop. The distinct dentate black line on the forewing enables this species to be recognised. *E. punicærella*, Mo., is described as boring in the fruits of the pomegranate in Baluchistan (Ind. Mus. Notes, II, p. 28). It does not seem to be known from further East. *E. cedrella*, Hmpsn., has been reared from the cones of deodar (*Cedrus libani*) in Kulu (Hampson, J. Bo. N. Hist. Soc., XV, 24).

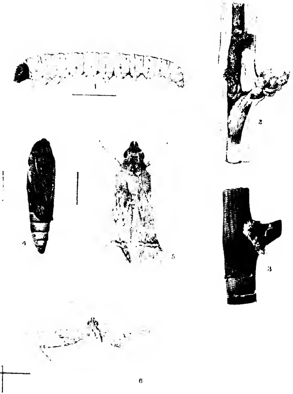
Microthrix inconspicuella, Rag., was reared from cane by Mr. Mackenzie, but is rare and is not commonly found. *Nephopteryx* is a large genus, whose larvæ usually feed on leaves; *N. eugraphella*, Rag., feeds on the Bukal tree (*Mimusops elengi*). N. *semirubella*, Scop., has been reared from maize leaf and is stated to feed on other plants. The moth has the costal half of the wing whitish, a colouring which occurs in a number of *Pyralids*. *N. paurosema*, Meyr., has been reared from larvæ boring in the pods of Chakaur (*Cassia tora*) and appears to be common in the plains. *Epicrocis* contains two species extremely common in long grass in the plains in October, both small brown moths, with pink suffusion. *E. ægnusalis*, Wlk., has the hindwing ochreous, *E. laterilialis*, Wlk., has it fuscous and has a whitish fascia along the costa. *Hypsipyla* (Magiria) *robusta*, Mo., is the species whose caterpillar bores the shoots of Toon (*Cedrela toona*) in the Punjab; the damage is extremely characteristic, each shoot dying back from the tip and the pest is a serious obstacle to the growth of this shade tree in some places. An account with figures will be found in Indian Museum Notes, Vol. I, p. 35; a fuller one in Vol. V, p. 104. It also bores in Mahogany and is recorded as destroying young plants (loc. cit. I, p. 66).

Another pest is the cotton bud moth, *Phycita infusella*, Meyr., widely spread over India and fully described in Indian Insect Pests (page 99). *P. clientella*, Zell., is the common and widespread leaf roller of the brinjal plant and of wild *Solanum*. *P. dentilinella*, Hmpsn., was reared from larvæ feeding on cocoons of *Cricula trifenestrata* brought from Commilla and the larvæ fed freely on the dried moths. They appear to be feeders on dry chitin, etc. This genus is a large and important one, the males with a great variety of modifications of palpi and antennæ, as is also the case in *Nephopteryx*. Careful collecting and breeding will probably show that there are many widespread and common plains species breeding in wild plants.

PLATE XLVIII.—EUZOPHERA PERTICELLA.

BRINJAL STEM BORER.

Fig. 1. Larva.
,, 2. Bored stem of egg-plant (*Solanum melongena*), cut open.
,, 3. The same as seen from outside.
,, 4. Pupa.
,, 5 Imago.



BRINJAL STEM BORER

Etiella is represented by *E. zinckenella*, Treitschke. It is a common pest of cold weather pulses, and of sann hemp (*Crotalaria*), the bright red or green larva feeding in the pods; the little moth is grey, the costa white-edged, the forewing with a transverse ridge of raised scales near the base. It is often extremely abundant and does a considerable amount of damage to many varieties of pulse.

Epipaschiinæ.—A small sub-family including seven genera of moths approximating in appearance to the *Bombycine* type. The larvæ live in colonies and form social cocoons. No species appear to be common in the plains.

Chrysauginæ.—A neotropical sub-family with two genera recorded in India, not found in the plains.

Endotrichinæ.—Slender moths, forming nine Indian genera, distinguished by the venation, not occurring in tropical India.

Pyralinæ.—A sub-family of thirty genera, recorded almost wholly from hill localities. The character of the venation serves to distinguish the group, while the structure of the palpi, maxillary palpi and wings must be compared for the identification of genera. *Pyralis* includes the pretty moth, *Pyralis farinalis*, Linn., found commonly on walls of houses, whose larva feeds in oatmeal, potatoes and similar vegetable substances and is a cosmopolitan household pest. *Hypsopygia mauritialis*, Boisd., was reared from a caterpillar found at the roots of a Sissu tree (*Dalbergia sissu*; Plate XLII, figs. 5, 6). It has since been found to live as a larva in the nests of *Polistes hebræus*, feeding on the wax and destroying the larvæ and pupæ.

Hydrocampinæ.—Slender moths, with long legs; many species are common in the plains, and over thirty genera are recorded. Many more remain to be described. The larvæ of some are aquatic, living actually in water and breathing by means of gills or at the surface and breathing air directly.

Nymphula is universally distributed and common in India. The known larvæ are aquatic, the body having tubular gills, with tracheal tubes in them, air being apparently obtained by transpiration through the thin gill-walls, and spiracles, though present, being closed and functionless. *N. depunctalis*, Guen. (Plate XLIX), is a common species, destructive to rice; the larva rolls a leaf and lives within, being able to live in water or air; the moth is white, speckled with black and buff. Wood-Mason describes the larva and pupa of a species which Hampson thought might be *N. fluctuosalis*, Zell., under the name *Paraponyx oryzalis*, W. M. (Rice Pest of Burma, Calcutta, 1885), but this is likely to be the above species, which is known from practically all rice tracts in India. Other species live upon aquatic plants in tanks and rivers, the moths commonly found at light and in grass. *N. affinialis*, Guen., is found commonly in rivers, feeding on aquatic plants.

Scopariinæ.—Three genera of small moths whose larvæ "feed on mosses and lichens, and the imagos rest on rocks and trees" (Hampson). All recorded are hill species.

Pyraustinæ.—A very large assemblage of moths with over 90 genera and 500 species in India. The larvæ are often leaf rollers, a few living exposed or boring in plants. Many can be readily reared on their common foodplants or can be captured in the plains, and this sub-family includes the larger number of *Pyralids*, the student will commonly find or rear. Only the more common species whose larvæ will be found, can be noticed in this place. *Zinckenia fascialis*, Cram., is deep brown with white markings. The larva is green, with white lines and with black crescents on the thorax below the lateral line. The leaves of cultivated *Amaranthus* are commonly webbed up by this larva, which can be found in almost any garden during the warmer months; the moth is common on plants and comes to light. There are other foodplants such as beetroot, maize and other garden plants.

A common moth in moist localities is the little dusky-fringed buff-coloured *Cnaphalocrocis medinalis*, Guen. The larva lives on the leaf of rice and some grasses, folding over the edge of the leaf and fastening it with a few silk strands; it is an occasional pest of rice and widespread over the plains. The male is conspicuous by the erect tufts on the upper surface of the forewing. *Marasmia trapezalis*, Guen., behaves very similarly on maize, juar and bajra during the rains. (Indian Insect Pests, p. 138.) It folds over the edge of the leaf and lives in the fold, emerging to eat the epidermis outside. It is a pest only to small plots of maize and is not sufficiently abundant, being checked by parasites, to do any harm to large areas of crops.

Syngamia includes three small yellow-red moths common in the plains. *S. abruptalis*, Wlk., has been reared from leaf-rolling caterpillars on tulsi (*Ocimum sanctum*). *Bocchoris* includes several species of wide distribution. The fact that some number of these fragile moths should be common to such wide areas, including the tropics of both hemispheres, is striking, and one may wonder how they spread so widely. *Caprinia conchylalis*, Guen., is a larger moth, pure white with the forewing edged with a costal brown band, the male with a black anal tuft. The whole appearance is much like *Glyphodes perspectalis*, Wlk., which is slightly smaller. The larva in Ceylon feeds upon the leaf of *Kicksia* (Green), and on *Holarrhena antidysenterica* (Grote).

Filodes fulvidorsalis, Hubn., is a brightly coloured insect with dull brown wings variegated with orange. The antennæ are long, the abdomen long with lateral tufts. The larva is olive green, with black spots and white bands, feeding upon *Thunbergia*. *Nevrina procopia*, Cram., is a striking moth, the base of the wings orange, the outer half dull purple with white veins. *Dichocrocis punctiferalis*, Guen. (Plate L), is a bright-yellow black-speckled moth, whose larva destroys the stems and seeds of the castor plant, boring in them. It is common throughout the year and may be so abundant as to cause much damage. It also feeds on kaikar (*Garuga pinnata*) fruits in Poona, on Cacao in Ceylon (Green), and in mango flowers in Nagpur.

Nacoleia diemenalis, Guen., has been reared in Pusa from leaf-rolling caterpillars on Urid (*Phaseolus mungo*). *N. vulgalis*, Guen., is very common on pulses during the rains, the larva rolling the leaves and being destructive to young plants. Its foodplants include Lucerne, soy bean and *Phaseolus radiatus*. *Botyodes asialis*, Guen., is a larger orange moth, with some clouded markings, and the male with a black anal tuft, whose larva is found on the leaves of *Ficus*. The larva is olive green with black spots. *Sylepta* is a large genus of many species, the larvæ being leaf-rollers and feeding upon wild and cultivated plants. *S. derogata*, F. (*multilinealis*, Guen.), is the most common, the green larva rolling the leaves of cotton, bhindi, hollyhock and other malvaceous plants. This has a wide distribution and is a pest in Africa as well as India. (See Mem. Agric. Dept., Vol II. No. 6.) *S. lunalis*, Guen., feeds on the leaf of the grape vine; the moth is a dull fuscous with faint darker markings.

Lygropia includes several orange moths with dull markings common throughout India. *L. quaternalis*, Zell., has been reared from bariar (*Sida rhombifolia*). *Agathodes ostentalis*, Hubn., is a pretty pale greenish moth with a pink fascia on the forewing, whose larva has been found feeding on the Pangra tree (*Erythrina indica*) in Calcutta. (Indian Mus. Notes, Vol. V, p. 129.)

Amongst the largest genera is *Glyphodes*, with a considerable number of species found in the plains. The larvæ are leaf-rollers, living in twisted leaves and feeding on neighbouring portions outside. They are commonly light green or the semi-transparent greenish colour of so many leaf-rolling pyralid caterpillars. Any of the following thirteen species are likely to be found and their identification is possible only by careful comparison with accurate descriptions. *G. vertumnalis*, Guen., *G. glauculalis*, Guen., *G. psittacalis*, Hubn., and *G. pomonalis*, Guen., are green; the first is common on the leaves of the white flowering, *Tabernæmontana coronaria* in gardens (Plate XXVIII, fig. 7). *G. unionalis*, Hubn., is white with a brown costal fascia and feeds on the flowers of *Jasminum sambac*: *G. laticostalis*, Guen., is similar, the costal fascia cupreous, the male antennæ dilated and twisted at the base; *G. nigropunctalis*, Bren., is white with a broader brown costal fascia and some black spots on the forewing. *G. indica*, Saund., is very widely spread, the forewing white and black, the male with a conspicuous tuft of long scales. The larva is common on *Cucurbitaceous* plants. *G. bicolor*, Swains., is black-brown, conspicuously marked with white, as also is *G. bivitralis*, Guen., in which the ground colour of the forewing is chestnut, the marks in the form of two semihyaline white blotches. *G. negatalis*, Wlk., is white and fuscous, the base of the male antenna dilated and tufted: de Nicéville figures the moth in Indian Museum Notes (Vol. V, pl. XV), and he records rearing it from Pipal (*Ficus religiosa*) and on the fruits of chalta (*Dillenia indica*). *G. celsalis*, Wlk., and *G. pyloalis*, Wlk., are white, brown and fulvous.

Lepyrodes perspicata, Fabr. (*neptis*, Cram.), feeds upon *Jasminum sambac* in the plains, the larva rolling the leaves after the usual manner, while *L. geometralis*, Guen., has been reared from a larva found feeding upon the flowers of the same plant. *Leucinodes orbonalis*, Guen., a small white moth with dull ferruginous and black markings, is common throughout the plains, its caterpillar being the borer of the fruit of the wild and cultivated brinjal or egg plant (*Solanum melongena*). The larva is pink, smooth and almost hairless as are most boring larvæ.

The male of *Crocidolomia binotalis*, Zell., has a tuft of long hair on the forewing, and is ochreous with ferruginous markings. The caterpillar lives upon cruciferous plants, including cultivated cabbage and 'halim' (*Lepidium sativum*) and appears abundantly in the hot weather in April in gardens. It is green with median and lateral white stripes, a black prothoracic shield and three black dots on the side of each segment. Another small caterpillar that feeds on cabbage and cauliflower at the same time is *Hellula undalis*. Fabr., a small white-marked greyish moth which has a very wide distribution in the tropics.

Isocentris ophelt esalis, Wlk., has been reared from larvæ found upon sunflower plants. The larva is green with a dorsal white stripe on each side of the median line and a crescent shaped black spot on the mesonotum on each side. *Maruca testulalis*, Gey., is a rather larger moth fuscous, brown with a semi-transparent band in the forewing and a large part of the hindwing semi-transparent. Its larva feeds upon pulse, entering the pod at one end and going completely through; it is the usual smooth larva greenish-yellow in colour, with small spots on each segment. It occurs abundantly in the rains on pulses and is widespread in India. *Nomophila noctuella*, Schiff., is likely to confuse those who attempt to place moths on their general appearance alone since it has the appearance of a *Noctuid*. Hampson remarks: "Universally distributed." *Pachyzancla licarsisalis*, Wlk., and *P. phæopteralis*, Guen., are fuscous moths in which the mid-femora of the male are dilated and clothed with scales; both are common and widespread, the latter having been reared from green larvæ which roll the leaves of *Anisomeles ovata*. *P. ægrotalis*, Wlk., is a small brownish orange moth, whose green cater-

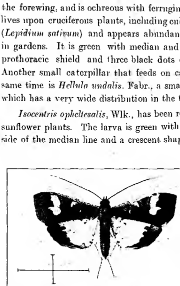


Fig. 342. MARUCA TESTULALIS. [I. M. N.]

pillar webs up the leaves of croton, *Alternanthera* and *Schizandra* in the rains and feeds there. *Phlyctænodes nudalis*, Hubn., is a small straw-coloured moth which has been reared from fenugreek (*Trigonella fœnum-græcum*) and croton, but does not appear to be common. *Diasemia ramburialis*, Dup., is black with ochreous markings and white spots found abundantly in the plains, and also according to Hampson, universally distributed.

Antigastra catalaunalis, Dup. (Plate LI), is a common and abundant pest to til (*Sesamum indicum*); the larva is light-green, with many black spots bearing hairs; it rolls the leaf of the til plant or bores into the seed pods. The larva readily lets itself down with a thread and eventually descends to the soil to pupate. The moth is ochreous with reddish veins and is easy to recognise. While commonly occurring only in the rains, it breeds throughout the year if its foodplant is available. The caterpillar of *Noorda blitealis*, Wlk., is found on the horse-radish tree (*Moringa pterygosperma*); the moth lays a white egg on the edge of the leaf, from which comes a white larva which later turns green; the larva folds the leaf over or joins two together and feeds on the epidermis. The pupa is in a fine silken cocoon. This species is found breeding during the rains and is widespread in India. *Metasia coniotalis*, Hmpsn., has been reared from larvæ feeding in the tubers of sweet potato in Pusa (Plate LII, figs. 1-4).

Pionea ferrugalis, Hubn., is a small yellow moth widespread over Europe, Africa, Asia, whose larva in India feeds on cabbage and kakaronda (*Blumea balsamifera*). It is found as a larva during the cold weather and is likely to be a "cold weather species," only breeding at that time.

Pyrausta is a large genus of mostly hill forms. The life-history of *P. machœralis*, Wlk., is described and figured by R. S. Hole in the Journal of the Bombay Natural History Society, Vol. XV, p. 679; it feeds on teak. *P. coclesalis*, Wlk., is a brown moth, common on the plains, whose larva feeds upon bamboo and is occasionally found upon maize. The larva of *P. salentialis*, Snell, feeds upon a species of *Polygonum*, boring the stem and pupating there; it is an unusual habit for one of this genus. Hibernation as a larva occurs in the stem.

PLATE LI.—ANTIGASTRA [illegible]
TIL LEAF ROLLER.

Fig. 1. Shoot of Til (*Sesamum indicum*) rolled by the larva.
,, 2. Another shoot, showing the larva, as it lets itself down by the thread.
,, 3. Larva magnified.
,, 4. Pupa ,,
,, 5. ,, in its cocoon.
,, 6. Moth. Natural size.
,, 7. Moth magnified.
,, 8. Eggs on leaf.
,, 9. ,, magnified.
,, 10. Newly hatched larva feeding on the epidermis prior to webbing the shoot.

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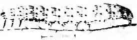

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Collecting.—*Pyralids* abound everywhere, but it is not always one can get good unrubbed specimens. All that can be reared should be and the best specimens are thus obtained. Setting is troublesome and it is best to keep all in papers till time allows of a whole batch being done at once. Larvæ may be blown or kept in formalin. They are found by patient seeking on plants, wherever rolled leaves are seen among decaying vegetation and leaves at the roots of grasses in grass stems. A great fauna of *Pyralids* centres round grassy plants and few of such have been reared or studied. The wilder grasslands of India must abound in such forms and will prove a paradise to the collector of these moths.

HOW INSECTS PROTECT THEMSELVES.

A large part of the insect world is engaged in preying upon other insects, and while we do not know how far every insect has enemies directly attacking it in this manner, it is at least certain that a very large proportion are the food of either ordinary predators, stinging predators, insectivorous birds, lizards, frogs and the like or are the hosts of parasites. The insect organization reveals a variety of devices believed to be directed to securing a measure of immunity against these enemies, and it is possible to mention the more obvious ways in which immunity is aimed at; we cannot justly say that it is in all cases proved that these devices do secure immunity or do actually increase the measure of safety under which each insect lives: but the prevailing conclusions drawn from a mass of observations by the general body of observers is that these devices have little or no other meaning, and can be rationally explained in full only on the assumption that they are of value to the insect in this connection. Speaking broadly, the insect adopts one of four general methods: (1) to be distasteful: (2) to look distasteful; (3) to escape observation; (4) to frighten enemies.

Many insects are known to be distasteful to birds and insect-eating animals, on whom we can experiment; we associate this distastefulness with scents in many cases, scents produced by the excretion, at the will of the insect, of the aromatic oils. Most of our *Pentatomidæ* are excellent examples: they have special orifices on the ventral surface whence issues a liquid which volatilises with the production of a usually very marked scent: it is only necessary to bring this scent within perceptive reach of birds and some animals to see unmistakable signs of aversion. The scents are often disagreeable to ourselves, but far less so than they are to animals. Such scents are found in ***Pentatomidæ***, *Coreidæ*, *Lygæidæ*, *Pyrrhocoridæ*, some *Reduviidæ* and

Cimicidæ in a strong degree; *Myrmeleo*, *Ascalaphus*, *Chrysopa* and some other *Hemerobiidæ* exhibit the same phenomenon; and a number of beetles, notably perhaps the *Carabidæ*, some *Cerambycidæ* and some *Cicindelidæ* can be added.

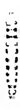
We cannot clearly separate the production of scent from the production of oil or fluid, having not only a scent but either a bad taste or some caustic property. Many *Coccinellidæ* excrete such oils as notably do the *Cantharidæ*; *Blaps* and other large *Tenebrionidæ*, *Aularches* and *Pœcilocera* among *Acridiidæ*, are also conspicuous examples, and it is reasonable to conclude that the effect of this secretion of fluid is quick in effect, the bird or beetle seizing such an insect promptly getting the taste or caustic result of the oil and dropping its prey at once. In the case of *Aularches* and of several of the Chalcosiine division of Zygænids, *e.g.* (*Campylotes*), the fluid is not only secreted but bubbles out at the orifice, forming a mass of bubbles similar to that produced by *Cercopidæ*: the curiously sudden way in which this happens is very striking, not to say alarming. A number of insects which do not produce scent or oil are apparently distasteful on account of the presence in their tissues of distasteful substances, either due to the secretion of some constituent for this purpose or due to the food they take in; the *Danaides* are examples of such insects as are also the *Coccinellides* and *Cantharides*. In the majority of these cases we find that with distastefulness is combined a system of warning colouration which advertises the fact, or which is sufficiently vivid to be associated with the distastefulness in the mind of the predator. That is, most distasteful insects are "warningly coloured," so as to secure the maximum protection from their distastefulness by plainly indicating that they are distasteful. We are not here discussing colouration, but we shall have need to refer to this fact again. The number of groups in which warning colouring occurs is very large.

A rather doubtful device is the extremely hard and thick integument of some insects, beetles especially, often combined with horns, spines or other projections calculated to be troublesome to the consumer. It is difficult to find any other value in the intensely thick hard portions of the integument of some beetles, as also in the hard knobs and spines of many *Pentatomidæ*, for instance, and we may conjecture that the possession of such an integument does turn the scale in favour of the possessor and against some unarmed insect equally available at the moment.

Another device is to be found in the hairiness of so many caterpillars: there is good ground to believe that a hairy caterpillar is not as palatable to a bird, for instance, as is a smooth hairless one, and when we consider how indigestible chitin is and how much room the hairs take up, we can imagine why. This device is carried to an extreme when the hairs themselves are poisonous as is often the case; hairy caterpillars occur principally in the *Lymantriidæ*, *Lasiocampidæ*, *Eupterotidæ*, *Limacodidæ* and *Arctiidæ*: those with poisoned hairs chiefly in the two former rarely in the last.

PLATE LII.—MICROLEPIDO

Fig. 1. *Metasia coniotalis*, Hmpsn. Larva.
,, 2. }
,, 3. } ,, ,, ,, Pupa.
,, 4. ,, ,,
,, 5. *Hypsopygia mauritialis*. Larva.
,, 6. ,, ,, Imago. x 2.
,, 7. }
,, 8. } *Phycodes radiata*. Larva.
,, 9. ,, ,, Empty pupa case and cocoon. x 3
,, 10. ,, ,, Moth. x 2.



Finally, under our first category, we may include the very simple device of the insect which covers itself with its excrement or which carries with it a pile of its cast skins or the cast skins of its prey, or which encases itself in inedible and unpleasant material. The larvæ of some *Chrysomelidæ* are notorious for carrying their excrement; many Cassidides do this, having a special process to carry it on, and having the opening of the alimentary canal placed so far dorsally that the excrement can be retained; the larva of *Podontia* does this, as do some *Criocerides*. The larva of the predaceous *Chrysopa* goes about carrying a pile of the sucked out skins of its victims (see fig. 76, page 154), while some Lepidopterous larvæ wear their old cast skins (*e.g.*, *Rœselia fola* which carries the cast head-cases) (fig. 301, page 436). It is probable that the case of the Psychid larva made of dry twigs or leaves is mainly protective in the sense that the bird does not care for the caterpillar with its outer case of dry material and so leaves it alone. The same is probably true of Caddis larvæ (*Trichoptera*) which live in cases of small stones, shells and other indigestible materials.

A number of species try to look distasteful; they may do this in two ways, by looking like some unpleasant object, by looking like some insect that is of itself unpleasant. Of the first, the most conspicuous are perhaps those insects which look like the droppings of birds; a good example is the young larva of *Papilio demolius*; this starts life as an ordinary butterfly caterpillar of a dull brown colour; it soon becomes white over a large part of its body (fig. 292, page 422), and when not feeding, rests motionless on a leaf in the full view of all birds that pass: instead of hiding among the leaves, it conspicuously shows itself; to us it is a very good imitation; perhaps it is to a flying bird also. Another conspicuous example is the genus *Tarache*; the moth of *T. notabilis* is white with dull black markings; instead of seeking shelter by day as most Noctuids do, it sits motionless on the top leaf of its foodplant, the wings closely applied to its body; it has the shape and appearance of a bird's excreta, and we believe it is sufficiently successful to escape its foe in that way. All the species of *Tarache* behave like this.

We have referred above to the warning colouration of insects that *are distasteful*; but a very large class of insects that really are not distasteful adopt this colouring and pretend to be; an example is figured in the family *Zygœnidæ*. This mimicry of distasteful species may take two forms; an insect will be found to very closely imitate another found in the same locality; or a whole number of insects in one place will be found to have a general scheme of warning colouring (*e.g.*, black and yellow) part of them being really distasteful, part being mimics; the birds may, if the former are sufficiently numerous, associate this colouring with unpleasant insects and so leave all alone; one would imagine that the 'frauds' must add to the slaughter also of the genuinely distasteful ones, as if for instance, there were equal numbers of both, birds might go on trying for a long time and never be quite certain what they were going to get. This subject is dealt with in two notable papers (Trans. Ent. Soc., London, 1902, p. 287, and Proc. Zool. Soc., London, 1902, II. p. 230), and with a vast wealth of confusing nomenclature in Beddard's "Colour of Animals." The sincere student with a profound faith in human nature may be cautioned against accepting any conclusions or facts not based on observation of insects in their natural conditions: the search for explanations of insect colouring has almost rendered the whole subject ridiculous since conclusions have been drawn from Museum specimens, which have no relation to the lives of insects; but it does not require much field observation to convince the student that mimicry of this kind is a real feature of insect life.

In our second division we have included such insects as make special efforts to conceal themselves. Possibly this applies to every insect, except such as are protected by devices coming under other heads. A great number of caterpillars, for instance, feed at night only; so do most moths; *Perlidæ Ephemeridæ* and some other *Neuroptera* appear only at night, when most birds are asleep and their chance of escaping is greater. These and other insects must also protect themselves during the day: a green caterpillar sitting motionless among green leaves does probably escape the observation of predatory birds, wasps, etc., more often than one not so coloured; the combination of such colouring with the habit of resting motionless by day is very common indeed, and when one realizes how constantly birds, wasps and stinging predators are searching for caterpillars, one can believe that the colouring and attitude are essential to the continuance of that species. We need not dilate upon this; any observer of nature can see it for himself; moths are extremely often found sitting motionless on bark, coloured like bark and really quite indistinguishable; a great variety of insects are of this colour: more are leaf-like or are sufficiently green to be invisible among green leaves; the grass mantid is a splendid example of an insect that is invisible in grass; throughout the pages of this book we note examples, and they are not more fully illustrated for the simple reason that in a truthful illustration the insect would not be seen, and if the illustration accents the insect enough for it to be seen, it is not truthful.

Finally there are insects that are supposed to escape by startling or frightening their enemies; we deal with this subject very cautiously because what startles us may not *really* startle a bird or a toad or a predaceous beetle at all; in this subject again, conclusions have been freely drawn from insufficient data. The resemblance to a snake or to some weird large-eyed creature is one that is often quoted, for instance, in sphingid larvæ; the apex of the wing of the atlas moth is said to look like a cobra's head; the full grown larva of *Papilio demoleus* is said to be snake-like; the caterpillar of the notodontid, *Stauropus alternus*, looks like nothing else and is supposed to frighten its foes; the large sphingid caterpillar in the Himalayas which waggles its head backwards and forwards, at the same time hissing, may frighten birds off: the caterpillars that suddenly extrude yellow or red processes, or which draw themselves up and display eye-markings or bands of colour; these are all instances of possible efforts at escape by startling or frightening an enemy. They are striking to see and, if we could see them in proper proportion might be very effective to us; if a six-foot caterpillar suddenly hissed and two six-inch eye-spots glared at me I might be frightened. We cannot estimate these things properly because it is not known against what enemy they are aimed. It is probable that some are effective, that some were once effective or are becoming so and that we misinterpret many.

The following summary of the more important devices used by insects may be of assistance to the student:—

1. Hard integument.
2. Hairs and hairiness.
3. Stinging hairs.
4. Secretion of distasteful substances. (With warning colouring.)
5. Use of excrement.
6. Use of cast skins.
7. Protective and cryptic colouring form and attitude. Shamming dead.
8. Batesian mimicry. (Mimicry of a warningly coloured distasteful insect.)
9. Mullerian Mimicry. (Adoption of a general scheme of warning colouring by edible as well as inedible insects.)
10. Misleading and deceptive colouring.
11. Terrifying devices, sounds. etc.
12. Resemblance to unpleasant substances.

In the above pages we have tried to indicate what is known. but we have no wish to give the impression that much is known: every observation bearing on this subject is worth recording; every record of one insect actually found preying on another is valuable, provided both insects are identified at least to genus and if possible to species: impressions gained from general observation are by no means so good as actual deductions from a mass of definite facts and it is to be hoped that this subject will meet with the attention it deserves in this country.

We may close this subject by remarking that every student should bear it in mind when in the field; the observation of living insects in the field is the least prosecuted branch of enquiry and it is well to keep an open mind on the subject: an insect mimicking a distasteful insect may not now have the same distribution as its model. and this is, of course, a source of confusion unless one knows this: there are many other misleading factors. but it is a sound practice to look at every insect with this problem in view. not straining it. not blinding oneself to facts, but honestly endeavouring to penetrate to the truth.

ORNEODIDÆ. (ALUCITIDÆ).

The forewing divided into six distinct plumes.

Less than ten species are recorded from India, wholly from the hills. A larger number is known from Ceylon ; the genus *Orneodes* includes our species, none of which will be found in the plains. The student will find descriptions in Meyrick's papers in the Bombay Journal and elsewhere (Trans. Ent. Soc., London, 1907, p. 507).

PTEROPHORIDÆ.

Small slender moths, in which the forewings are narrow and divided into two, three or four narrow lobes, the hindwings of one, two or three lobes.

These moths are clearly recognisable from their form and the structure of the wings. Their appearance is extremely graceful, as they rest on leaves with the wings and legs extended and fly somewhat slowly. Their colours are light, dull ochre and brown on a lighter ground colour as a rule. The body is slender, the abdomen ovate and long ; the long narrow wings are fringed with scales which in some species are in part capitate and rather large. The tiny legs are conspicuously spurred and in some species the hindlegs are held out over the body and very noticeable.

Of the few known Indian species several are known in the larval stage. The eggs are oval, not flattened, and smooth, laid singly on the foodplant (Plate LIII) ; the larvæ are slender, oval, the body set with spines and with capitate hairs which radiate from tubercular points : they feed openly, as a rule, and are cryptically coloured to resemble the foodplant. Their perfectly oval form, the indistinctness of their segmentation, their clothing of hairs and spines, these characters render them recognisable ; if a pupa is also found, there can be no doubt as to the recognition of the family since the pupa closely resembles the larva, having almost the same shape, the same colour, with the same covering of hairs and spines and lying openly on the foodplant as does the larva. It is soft and quite unlike the ordinary pupa of this order, being attached by a cremaster, and in some cases by a few threads of silk under the abdomen in which the hairs are entangled. Indian Pterophorids are but incompletely known, and Meyrick has recently described a number of species. (See Journ. of Bombay Nat. Hist. Soc. and Trans. Ent. Soc., London, 1907, p. 472.) At least two are injurious to agriculture and occur widely in India; others are known from different foodplants or have simply been captured. Over forty Indian species are described, largely from the Khasi Hills and South India; some are widely spread, *e.g.*, *Trichoptilus congrualis*, Wlk., found generally over the tropics.

Exelastis atomosa, Wals. (Plate LIII), is one common species in the plains, a delicate dry-grass-coloured insect with an expanse of 20 m.m. The eggs are laid singly on the flower buds, young pods and more rarely the leaves of the foodplant, which is commonly the pigeon pea (*Cajanus indicus*). The egg is oval, not flattened and not reticulate, of a greenish colour. A single moth has been found to lay 94 eggs, these hatching in about 4 days in hot weather. The larva feeds by eating into the soft growing pod and then into the young seed; it remains partly outside on the pod, stretching in to get the seed and not wholly entering the pod. Having eaten one seed it makes a fresh hole opposite another. The larva is green or brown, or a mixture of both and closely resembles the colouring of the pod. The body is clothed with a dense pubescence of short spines and longer capitate hairs radiating from tubercular points. The median dorsal line is longitudinally indented with a slight ridge on each side. The larval life is from 2 to 4 weeks, depending on the temperature; before pupation the larva spins a little pad of silk and also a light network: the apex of the abdomen bears hooks that are fixed in the pod, the hairs of the pupa being entangled in the network: the pupa is thus fixed to the pod in an exposed position; it is soft, green or brown in colour with a close resemblance to the larva and with limbs and wings which are not fixed to the body, but are held in a straight line along the ventral surface. The anterior half of the pupa can be raised when the insect is disturbed. The moth hangs from the plant by the anterior legs, the hindlegs held out over the body, the wings expanded but the hindwing so concealed under the forewing that it is not seen. The duration of life in this stage is apparently considerable, as moths live for over 10 days without food in confinement, and since the moth apparently lives over the time that foodplants are not available, waiting till she can lay eggs. This species is common throughout the plains and causes a considerable amount of destruction to pigeon pea in the cold weather. It is not recorded as breeding in the hot weather and rains, and probably lives over as a moth.

Sphenarches caffer, Zell., has a similar life-history and its larva occurs sparingly on the pigeon pea with it. It also breeds on the leaves of Cucurbitaceous plants during the hot weather and rains, and is thus found breeding practically throughout the year.

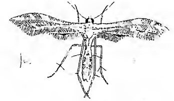


Fig. 343—SPHENARCHES CAFFER, RESTING ATTITUDE × 4.

Platyptilia brachymorpha. Meyr., is a moderately large brown moth, whose larva has been found eating into the flower buds of *Celsia coromondeliana*, a common wild plant in North India, growing during the cold weather. The larva is green with many brown scale-like hairs. *Deuterocopus tengstrœmi*, Zell., is a smaller ferruginous species, the forewing divided, the hindwing a simple capitate process, found sitting on plants. It occurs throughout the East.

Diacrotricha callimeres, Meyr., is found sitting on the leaves of *Averrhoa carambola*, in great abundance at some seasons. The small greyish moth is very graceful, sitting with expanded wings and hindlegs held out over the body. The little green larva feeds on the leaf, letting itself down actively on a long thread of silk in a very curious manner; the pupa is fixed to the leaf without any cocoon. Mr. Bainbrigge Fletcher has found the larva feeding in the flowers of *Averrhoa bilimbi* in Ceylon.

SESIIDÆ.

Clear wings.—Hindwing with vein 8 absent, vein 1c. present. Larva boring with 5 pairs of prolegs. Pupa in bore.

A family of small moths, most of which have clear wings and mimic Hymenoptera. The wings are small, narrow and hyaline, the body narrow, the antennæ moderately long and slightly clubbed; the legs are often tufted with long hairs; the flight is rapid and the moths are found flying in hot sunshine ; the resemblance to Hymenoptera is very marked, and in some cases it is known which species is mimicked. The wing expanse does not exceed two inches and is usually not more than one inch. Little is known of their life-histories, but so far as known, the larva is a borer in shoots of living plants, but has five pairs of prolegs : the pupa is in the shoot and is provided with hooks for moving in the galleries.

Trochilium ommatiæforme, Mo., in Baluchistan was found in Peshin attacking poplar. (See I. M. N. III, p. 14.) Of the fifty odd recorded Indian species practically all are hill forms and it is unlikely that many species will ever be found to occur in the plains.

Melittia chalciformis, Fabr., is well distributed over India, a small brown insect with bands of yellow. The specimens captured in the plains are rarities and these insects form no part of the real plains fauna.

TORTRICIDÆ.

Middle spurs of hind tibiæ well developed, palpi obtuse. Hindwing with vein 8 free or connected to cell by a bar. vein 1c. present.

Very little is yet known of this family in India and the student will recognise it only by the above characters. It is far less characteristic of the tropics than the next and has its greatest development in temperate regions.

The moths are small and somewhat dull coloured, sometimes with a characteristic appearance due to the rather long forewing, the rather heavy scaling and the manner in which the wings are wrapped round the abdomen. The antennæ are of moderate length, the eyes and ocelli well developed, the proboscis present, the labial palpi obtuse at the apex, the second joint roughly scaled.

The life-histories of few Indian species have been thoroughly worked out in all stages. Meyrick (Handbook of Lepidoptera) gives the following summary for the family as a whole : " Ovum flattened-oval, usually smooth, sometimes reticulate ; larva rather elongate, with few hairs, with ten prolegs, living concealed in rolled or joined leaves or spun shoots, or in stems, or flowerheads or roots. Usually there are no markings ; hence the leaf feeding forms, being often very polyphagous, are hardly to be discriminated. The head is often black when young and light-coloured later. Pupa with segments 8-11 free, in the male 12 also; protruded from the cocoon in emergence, usually in the situation where the larva fed." The protrusion of the pupa is worth note; in other respects the larvæ and pupæ are much like those of Tineids. The moths fly at dusk and are rarely seen.

The known Indian species include two destructive insects, the tur-leaf Caterpillar (*Eucelis critica,* Meyr.,) and the Sann stem borer (*Laspeyresia pseudonectis,* Meyr.). More are likely to be found and the notorious codlin-moth of the apple (*Carpocapsa pomonella* L.) is included in the family. But few Indian species have been described, these chiefly in the sub-family *Epiblemince.* The student will find descriptions in Meyrick's papers in the Bombay Journal. We mention such plains species as are known to us, but many remain to be found.

Of the *Epiblemince,* over 30 Indian species are recorded, of the *Tortricinæ* 40, two in *Ceracinæ* and one in the *Phaloniinæ*.

Epiblemince. Eucelis critica, Meyr., is a small dusky moth whose larva rolls the top leaves of pigeon pea (*Cajanus indicus*) in the rains. We figure the stages in Plate LV; an account is published in Indian Insect Pests, p. 143.

Eucosma paragramma, Meyr., has been reared from caterpillars boring in green bamboos; so few insects attack growing bamboos that it is interesting to find a caterpillar boring into so hard an object as a thick green bamboo. The larva is brown, with 5 pairs of prolegs, and pupates in the tunnel in the bamboo. *Laspeyresia jaculatrix,* Meyr., is a small dusky grey moth found sometimes in abundance flying in shady places. The larvæ are found in the bark of the sissu tree (*Dalbergia sissu*) and occur there abundantly. Pupation takes place in a fine silken cocoon. Apparently these larvæ are the hosts of a small Bombyliid fly, which has been reared from a batch of larvæ in sissu bark; the food of the larva is not known but it probably is the bark of the tree.

The caterpillars spend the winter in the bark of the tree and have a curious habit of coming out at night during a few days in March, crawling about on the bark and, soon after daylight, retreating into the bark again; immense numbers of them can be seen in the early morning on these days and the phenomenon is apparently so regular that the crows

PLATE LIV.—Laspeyresia Pseudonectis.

Sann Hemp Stem Borer.

Fig.	1.	Larva.
,,	2.	
,,	3.	Pupa case after emergence of moth.
,,	4.	Pupa.
,,	5	
,,	6.	Imago.
,,	7.	

[illegible] STEM BORER

pointed at the apex and commonly upturned. The legs are long and spurred, the wings variously held but not wrapped round the abdomen.

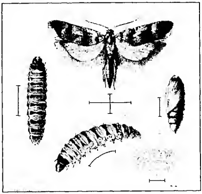


Fig. 341—GELECHIA GOSSYPIELLA, LARVA, PUPA, COCOON, IMAGO.

The life-history of a considerable number of Indian forms is known; the egg is flattened, oval or round, often reticulate above; eggs are so far as known laid singly. The larva is slender, usually with five pairs of prolegs, the body almost naked, and usually simply coloured, dirty white, orange, greenish or nearly black. The larval habits are extremely varied, some being seed-eaters, others living in spun leaves, boring in shoots, mining in leaves or in the bark of shoots; some are household pests in flour and dried food stuffs, some eat dried insects, wool, etc., a few eat lac, scale insects and mealy bugs, while probably many live in dried leaves, under bark and in other dead vegetable matter. Very little is known with regard to hibernation and the like. In the main, the larvæ are found when vegetation is most abundant in the moist months; these often hibernate as larvæ and pupæ, but *Leucoptera sphenograpta*, for instance, emerges very abundantly as a moth in January to await the putting forth of new leaves by the sissu trees in February. *Plutella cruciferarum*, Zell., is a "cold weather" species (as are some other insects probably spread from temperate regions) in the plains and is found abundantly then; it appears to spend the hot weather and rains in retirement at the roots of grass as an imago.

PLATE LV.—EUCELIS CRITICA.

THE LEAF ROLLER.

Fig. 1. Egg. Magnified.
" 2. Larva.
" 3. Second and third abdominal segments of the larva.
" 4. Habitation of the larva on the young plant of pigeon pea (*Cajanus indicus*), with the pupa case from which the moth has emerged.
" 5 } Imago.
" 6. }

FIR LEAF ROLLER

Several are destructive to agriculture and it is known that these are extensively parasitised by Hymenoptera; whether there are other checks is doubtful. On account of these injurious species the family has an importance near to that of *Noctuidæ* and *Pyralidæ*, and deserves very careful study. The number of new species obtained by rearing shows that there is a large field for work and systematic collection at light would yield many. For descriptions of species the student must consult especially Meyrick's papers in the Journal of the Bombay Natural History Society, from 1904 onwards. Three papers of Stainton's are valuable, in which he describes Indian species collected or reared by Atkinson. (Trans. Ent. Soc., London, n. s. III, p. 301 [1856]; loc. cit., n. s. V, p. 111 [1858]; loc. cit., 3rd ser.; I, p. 291 [1862]. There is otherwise little with regard to life-histories on record and we have referred below to the common species reared in tropical India.

Gelechiinæ.—Fifty species are recorded from India, of which a few have been reared; Stainton in 1856 described 9 species of this sub-family obtained in Calcutta by Atkinson. *Depressaria ricini*, St., was reared from a green larva with black head which rolled the edge of the leaf of Castor. *D. zizyphi*, St., fed on the ber tree; *D. ricinella*, St., was reared from a green larva with black head and prothoracic shield, also found rolling the leaf of castor.

Brachmia (*Gelechia*) *hibisci*, Stn., fed on *Hibiscus*. (See Trans. Ent. Soc., London, n. s. V, p. 111, for these and 14 other *Tineidæ*). It has been reared on bhinda (*Hibiscus esculentus*) in Behar, the larva living under a web on the ventral surface of a leaf and feeding on the lower epidermis. It pupates in webbed leaves. *Brachmia dilaticornis*, Wals., is a brown moth, large for a Tineid, whose larva feeds on the leaves of gular (*Ficus glomerata*). The larva grows to a length of two-thirds of an inch, of a sordid-white colour, with deep black hairs on the dorsal and lateral surfaces; it has a habit of curling up ventrally on being touched, showing the intersegmental constrictions. The full grown larva forms a cocoon of silk and hairs in a rolled up leaf; apparently the larvæ are nocturnal in habit as they are found by day in cracks in the bark. The moth has two distinct black spots on the forewing; it is apparently common, having been found on both sides of the Indian continent.

Ypsolophus includes two common plains species. *Y. ochrophanes*, Meyr., is common on such leguminous plants as lucerne (*Medicago sativa*).

and Guar bean (*Cyamopsis psoralioides*). The larva is green, smooth and nearly hairless, with small lateral black spots, and black head and prothoracic shield. It webs together two top leaves and lives within, eating holes in the neighbouring leaves. It is a common insect in the rains. *Y. evidantis*, Meyr., has a similar larva that lives on the buds and leaves of sissu (*Dalbergia sissu*), webbing the leaves together. Pupation takes place either between two leaflets or in the bark of the tree. The pupæ were also found in the bark of babul (*Acacia arabica*), but it is not known that the larva feeds on this plant.

Anarsia ephippias, Meyr., has a similar life-history and feeds on groundnut (*Arachis hypogea*). It has been found only in the rains and may have wild foodplants, probably *Leguminosæ*. It is figured in all stages in Plate LVI. *Anarsia melanoplecta*, Meyr., was described from a single specimen reared from a larva that bores down the green shoot of mango; its tunnel extends along the centre of the shoots till it reaches the limit of the new soft growth. It then pupates, after preparing an emergence hole, in a cocoon of silk and frass.

Anacampsis nerteria, Meyr., is the groundnut pest of Ceylon and South India, found also in the Sundarbans. The forewing is narrower, more bronzy in colour, with a light costal mark near the apex. The pest has been studied by Green in Ceylon who comments on the resemblance of the egg in miniature, to the groundnut itself. This insect is a serious pest, not yet known in Northern India, but likely to spread there. The larva is leaf mining and comes out to pupate in webbing between the two sides of a leaflet. It breeds also in *Psoralea corylifolia*.

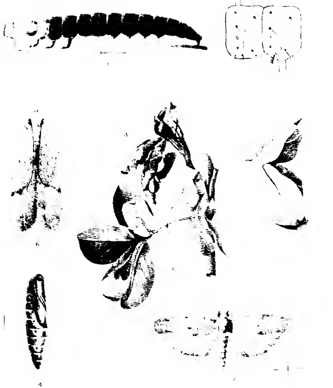
Gelechia gossypiella, Saund., was described by Saunders in 1843 from specimens sent from Broach. The larva is the notorious pink bollworm of India, Ceylon, Burmah, Straits Settlements and East Africa, whose life-history is discussed in Indian Insect Pests and the Agricultural Journal of India (Vol. I, No. 1). The larva bores into cotton bolls and feeds upon the oily seeds.

Gelechia tamaricella, Zell., is an European species bred from Jhau (*Tamarix gallica*) in Behar. The larva webs together several twigs, living inside this shelter and feeding on the dry leaves. *Gnorimoschema heliopa*, Low., is another widespread insect, whose larva bores in the stems of tobacco and other solanaceous plants. It is a widespread pest

PLATE LVI.—ANARSIA EPHIPPIAS.

GROUND-NUT LEAF ROLLER.

Fig. 1. Larva.
„ 2. Diagram of hairs on second and third abdominal segments of larva.
„ 3. Habitation of the larva on ground-nut shoot (*Arachis hypogea*) after the larva has left it and has pupated.
„ 4. Pupa.
„ 5. Pupa fixed to the leaf.
„ 6. } Imago.
„ 7. }



GROUND NUT LEAF ROLLER

in India, the larva causing swellings of the stems of young tobacco plants. The moth lays a single egg on the leaf stalk, the emerging larva boring down through the leaf stalk to the stem in which it lives. Pupation takes place inside the stem, the full grown larva preparing an exit hole through which the moth can escape. An account will be found in the Agricultural Journal of India, Vol. III, No. 1. *Binsitta niviferana*, Wlk., is a remarkable species of comparatively large size with very large upcurved palpi, the forewings snow-white with dark-markings, the hindwings yellow. The larva is a borer in the twigs of simul (*Bombax malabaricum*), entering at the leaf-axil and tunnelling in the centre of the shoot: it is a profuse producer of silk: there are five pairs of forelegs and little adaptation to the boring life. When full-fed the pupa emerges, spins a pad of silk and pupates openly on the branch or leaf: it is firmly attached by the many hooks of the cremaster and closely resembles a Lycænid pupa: there is no girdle but in shape it is like a Lycænid pupa and is quite naked and roughened. The moth rests by day openly on leaves and very closely mimics a bird's excrement. This remarkable insect is not uncommon in the plains, the larvæ being found in July. Bingham figures a pupa and imago of *B. barrowi*, Bingh., found on the same tree at Maymyo. (Trans. Ent. Soc., London, 1907, p. 177.) *Phthorimæa operculella*, Zell. (Lita solanella), is the destructive potato moth of the Mediterranean, United States, America and India. The life-history is shown on Plate LVII. It is almost certainly an importation to India with seed potatoes and has spread over Bombay, the Nilgiris, the Central Provinces and as far East as Patna. The larva mines in the leaves of the growing plant or bores in the tubers and the pest attacks both the growing plant and the stored tubers, being thus extremely destructive as the seed-potatoes kept from one season to another are destroyed. *Epithectis studiosa*, Meyr., feeds as a larva in dried herbarium plants in Ceylon (Meyrick). *Sitotroga cerealella*, Ol., is recorded from Kulu, as attacking maize cobs. It is widespread in India attracking stored cereals, rice especially.

Xylorytinæ.—Thirty-one Indian species have been recorded by Meyrick, mainly from the hills. Antram has reared *Metathrinca simblenta*, Meyr., from branches of tea (Meyrick). *Nephantis serinopa*, Meyr., has proved a serious pest to palms in Ceylon and South India, the blackheaded caterpillar stripping the leaves. *Procometis* (Hyostola) *trochala*, Meyr., is a very large moth for a Tineid, of the colour and form of a Galleriid moth, reared from larvæ found feeding upon the dry fallen leaves of sugarcane. The larva fixes two leaves together with silk and lives within, moving gradually along and placing cross threads as it goes, so that its excrement is caught in the threads and the path of the larva can be traced for over a foot between the leaves. It feeds on the dry leaf and pupates between the webbed leaves.

Œcophorinæ.—Six Indian species are described. This sub-family is notable for including a species commonly found upon lac in India, *Hypatima* (Blastobasis) *pulverea*, Meyr., having been reared from Bengal lac and occurring as a serious enemy to this valuable crop, with the various species of *Eublemma*. The larva feeds not only in the insect on the tree but in the dry shellac on the cut stick and it is necessary to fumigate the rains crop of lac to free it of the caterpillars, unless it is immediately scraped and manufactured. (See Agric. Journ. India, 111, No. 2.)

Stenominæ.—Four species of *Agriophora* are recorded by Meyrick, of which *Agriophora rhombota*, Meyr., is injurious to the tea plant. (Antram).

Copromorphinæ.—This includes two species of *Copromorpha* described by Meyrick from Assam.

Elachistinæ.—Less than twenty species of these small moths are recorded from India. *Laverna mimosæ*, St., is one of Atkinson's finds in Calcutta, the larva feeding on the seeds of *Mimosa* (? Acacia) *arabica*. *Stagmatophora promacha*, Meyr., was reared from a leaf mining larva found in *Phaseolus mungo*; the orange larva pupates in a thin cocoon of white silk. *Stagmatophora coriacella*, Meyr., is a tiny red-brown moth, which can be bred in abundance from dry cotton seeds left too long on the plant. The caterpillar is red, not unlike that of *Gelechia gossypiella*, only smaller and deeper coloured, and it is not found in the green boll or in unripe seed, as is this latter, and so is not destructive. We have reared this from cotton seed from many parts of India, and I. H. Burkill sent it in from Amherst, Burma.

The *Tinægeriidæ* of the Fauna of India, Vol. I, are included by Meyrick in *Elachistinæ*. These small moths are among the abundant insects of the plains, seen flying by day or sitting upon plants in the open. They superficially resemble Tineids, but are brightly coloured and are not crepuscular. The long hindlegs are held up in a striking manner when the little insect is at rest and one may commonly see the moths coupling on the top leaves of a plant. There are four Indian species mentioned by Hampson, of which two are common in the plains. *Œdematopoda clerodendronella*, Staint., has the forewing red, the hindwing orange. The larva feeds on *Clerodendron*, of which several species are common in waste lands, webbing together the top leaves. (See Stainton, Trans. Ent. Soc., London, 1856, p. 125.) It has been reared on *Clerodendron infortunatum* and *Anisomeles ovata*; the larva is brownish, with few short hairs and webs up the top of the shoot; it pupates in a thin silk cocoon in the bunch of leaves, the moth emerging inside the cocoon. It is found in the hot weather and rains in the plains. *O. cypris*, Meyr., was reared from a colony of lac (*Tachardia albizziæ*) in Ceylon (Green). *Eretmocera impactella*, Wlk., is far more common; the forewing, thorax and legs are metallic blue with yellow spots, the abdomen yellow with a dark band. *Stathmopoda* (Æoloscelis) *theoris*, Meyr., was reared from dark coloured slender larvæ found feeding in sunflower heads; the larva has a black head and prothoracic shield, the body naked, black, with five pairs of prolegs: the sunflower seeds do not appear to be eaten, but the dried remains of the flowers. Pupation took place in the head between the seeds. The moth is a slender insect, with narrow yellowish wings, the apical two-thirds brown.

Chlidanotinæ.—A small number of species known as yet only from Ceylon.

Gracilariinæ.—This sub-family has recently been listed by Meyrick (Journ. Bombay Nat. Hist. Soc. XVIII, No. 4), with 41 species recorded from India. *Lithocolletis triarcha*, Meyr., has been reared from larvæ mining the leaves of tree-cottons in the plains. The larva is flattened but has legs and five pairs of suckerfeet: the mine is visible on the lower surface of the leaf and the pupa is found in it. The moth is very small, with brown forewings bearing three oblique silvery bands. *L. bauhiniæ*, Stn., was bred in Calcutta by Atkinson, who describes the larva as mining the leaf of *Bauhinia purpurea* (Trans. Ent. Soc. London, 1856, p. 301. *Acrocercops* (Conopomorpha) *tricyma*, Meyr., is a tiny white and brown moth, whose larva mines the leaf of Kakaronda (*Blumea balsamifera*).

as many as four or five tiny green larvæ being found in one mine. The pupa is in a silken cocoon in the mine, the moths emerging in April and May. *A. telestis*, Meyr., was reared from a leaf-miner of Pitha (*Trema nudiflora*) in Behar and *A. phalarotis*, Meyr., from a similar leaf-miner in Chichira (*Achyranthes aspera*). *A.* (Gracilaria) *terminaliæ*, Stn., was bred by Atkinson from larvæ mining the leaves of country almond (*Terminalia catappa*). This and other Indian species are figured by Stainton (Trans. Ent. Soc., London, 1862, p. 291). *A.* (Gracilaria) *orientalis*, Stn., was described from specimens reared on Bauhinia by Atkinson (loc. cit., 1856, p. 301). *Gracilaria octopunctata*, Meyr., is a small dark moth with four yellowish spots on each forewing; the larva rolls the small leaves of sissu (*Dalbergia sissu*), forming a small mass of often dry leaves in which it lives and pupates. The pupa is sometimes in a web of very white glistening silk on a leaflet. *Gracilaria theivora*, Wlsm., is a pest to tea in India and Ceylon; the larva mines and rolls the leaf. (Ind. Mus. Notes, II, 49.)

Plutellinæ. Over twenty species are recorded from India, largely by Meyrick. *Simæthis orthogona*, Meyr., has been reared on Sahra (*Psoralia corylifolia*) in Behar; the larva is green with a brown head and a row of black tubercles on each side of the body; it feeds on the leaf, pupating under a slender white cocoon on the leaf; it is common yearly in July. *Phycodes radiata*, Ochs., is a rather conspicuous moth, common in the plains (Plate LII, figs. 7-10). The larva is a leaf-roller, feeding on pipal (*Ficus religiosa*) and other wild figs as well as on the cultivated fig (*Ficus carica*). It pupates either on the leaf or, if before winter, on the bark, making a stiff oval cocoon, flat and shiny. During winter it hibernates as a larva or pupa, moths emerging in April when there is another brood. *Brenthia buthusalis*, Wlk., is a delightful moth with broad wings delicately crumpled, which is found sitting on Marigold flowers during November and December; it is comparatively common, not easy to capture as it flies with a quick dancing motion when disturbed. *Plutella maculipennis*, Curt., the Diamond-back moth, is common on Cruciferous crops during the cold weather, especially in vegetable gardens. It is an almost cosmopolitan insect and, in India, spends the hot weather and rains as a resting imago in shelter.

Tineinæ.—About twenty species are recorded from India, a very small proportion probably of those occurring there. *Leucoptera spheno-*

grapta, Meyr., is a tiny white moth, the narrow forewing tinged with ochreous at the apex and with a distinct black apical spot and fuscous bars. The larva is a miner in the leaf of sissu (*Dalbergia sissu*) and is at times extremely destructive to young plants. The moth is curiously abundant in the cold weather when the leaves of the sissu fall, great numbers collecting in bushes, plants, wherever there is cover; at dusk they come out and fly about. When the sissu puts out young leaves in February, they lay their eggs, a single small egg on each leaflet. Tineids are not often a marked feature of the insect life of the plains, but this species cannot fail to be noticed in January and February, where this tree grows abundantly. *Crypsithyris longicornis*, Stn., is the moth whose larva lives in the little oval case found commonly on plastered walls in Indian houses; the case is of fragments and apparently spiders' webbing woven up with silk and the larva moves slowly along the wall. Its nourishment is apparently the size in the whitewash or some similar organic material. The pupa is in the case which is then hung from the ceiling by a thread, the pupa emerging

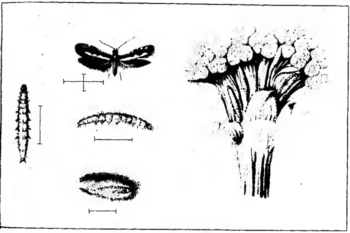


Fig. 345 PLUTELLA MACULIPENNIS [I. M. N.]

at the upper end for the moth to escape. This species is attacked by Hymenopterous parasites. The larva of *Opogona chalinota*, Meyr., feeds in the dry stem of Gurur (*Polypodium quercifolium*), reducing it to a mass of frass and dust amongst which the full grown larvæ pupate in white silken cocoons, covered with frass and dust. The larvæ were found in January, the moths continuing to emerge from the 1st February to 11th March. Green found the larvæ of *Opogona chalanitis*, Meyr., in the fungus beds of termites in Ceylon. *Setomorpha tineoides*, Wals., is not uncommon in dried tobacco leaves in India, and may do a considerable amount of damage if neglected (Plate XXVIII, fig. 10). *S. rutella*, Zell., is recorded as attacking blankets in Calcutta, *Tinea pachyspila*, Meyr., as living in a case on woollens and furs in bungalows in Ceylon (Meyrick), and *Tinea tapetzella*, Linn., was reared from wool in Calcutta. (Indian Mus. Notes, III. 5, 66.) Walsingham described a species as *Ereunetis seminivora*, which was bred from pods of *Cassia occidentalis* in Bengal. (Indian Mus. Notes, IV, 107.) The moth is dark chocolate brown with a pale ochreous band from base to apex of wing; the position of this species was uncertain owing to lack of material and until the species is found again. must remain doubtful. *Tischeria ptarmica*, Meyr., is recorded as mining in the leaves of ber (*Zizyphus jujuba*), at Puri, as many as twenty larvæ in one leaf (Meyrick, Rec. Ind. Mus., II, 399).

Dasyses rugosellus, Stn., is recorded as living in wood in India and Ceylon. (Indian Mus. Notes, V, 103.) It has been reared from larvæ found in mango and gular bark, as also in the frass of a Cerambycid borer in mango. It pupates in a silken cocoon in the dust or bark, the pupa wriggling partly out. *Strepsipleura cheradota*, Meyr., is a small brownish moth reared from larvæ found rolling the leaves of the pipal (*Ficus religiosa*).

Adelinæ.—One species of *Adela* and ten of *Nemotois* from sub-tropical India are included herein.

Collecting.—Every Tineid is worth collecting and pinning at once if it be in good condition. The wings need not be set, but those of one side at least must be separated from the body and from each other to admit of study. The finest silver pins on pith must be used. Besides collecting, much rearing has to be done and every one reared is a gain. Larvæ are not always easy to find, but chance throws them in the way of a collector who is looking for them and nothing else. Meyrick's printed instructions to collectors are useful, and Kearfott has an extremely valuable series of papers on collecting, pinning, etc., in the Entomological News (U. S. A.), for March, April and June 1904. Our knowledge of the group would be much increased if there were workers in this subject alone in so favourable a field as India.

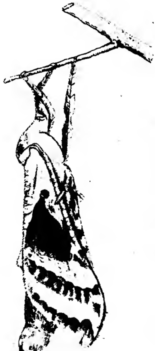


Fig. 346—Phassus malabaricus in resting attitude. × 1.

HEPIALIDÆ.

Both wings with twelve nervures, the cell of the hindwing emitting more than 6. No maxillary palpi or tibial spurs.

These are large moths of peculiar facies, found solely in the hills, none occurring, or very rarely, at low elevations or in the cultivated pains. They are regarded as the most generalised of existing moths, after the *Micropterygidæ*, the wings being but little specialised. The antennæ are short and filiform, the legs short, the proboscis not developed. The narrow wings and long body suggest the Cossid moth.

So far as known, the larvæ are borers in plants, often in roots. *Phassus* is the best known genus in India, with several large species. Only twelve are recorded as Indian. *Phassus malabaricus*, Mo., was reared from a larva boring a tea bush in the Nilgiris; the moth hangs by day by its forelegs, with the wings wrapped round it, in the position a flying fox or bat has. The larva bored down the root of the tea bush from the soil level, the pupa lying in the bore towards the opening.

THYSANOPTERA—*Thrips*.

Small insects, with two pairs of narrow fringed wings.

The order is very incompletely known in India, chiefly owing to the small size of the insects composing it. Our common forms are less than one-tenth of an inch long, of dull colouring. The head is short, the antennæ moderately long and inserted on the extreme front of the head; there are compound eyes and ocell and the inconspicuous mouthparts are on the under surface of the head towards the thorax. The trophi are peculiar and in some species are formed for lacerating the epidermal tissues of plants, the resulting sap or semi-liquid matter forming the food. In a number it is uncertain to what use the trophi are put, and it is stated that they are suctorial in function.

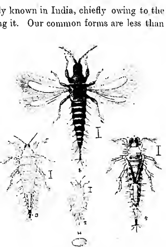


Fig. 347—THRIPS. 1—EGG. 2, 3—NYMPHS. 4—RESTING NYMPH. 5—IMAGO.

The thorax and abdomen are slender, the latter tapering to the apex; the wings are often reduced or absent—when present consisting of a slender stiff portion bearing a fringe of hairs on one or both sides. In repose they are carried over the abdomen. The apex of the abdomen is either composed of two valves or of a tubular structure; in many species a drop of liquid issues from this tubular end and is carried on long hairs until deposited. The legs are formed for running, are rarely used for leaping, and terminate in a one or two-jointed tarsus and a peculiar vesicle. There are many peculiarities of structure in the trophi, tracheal system, etc., which we cannot touch on here.

Extremely little is known of the life-history. Eggs are laid in or on the tissues of plants (usually leaves). under bark, in crevices on the soil and in other sheltered situations. There are said to be three moults in the life of the emerging nymph, which is similar in general structure to the adult; at the third moult the insect appears with external wing lobes and rests until with another moult, it becomes winged and mature. This fourth instar is then an intermediate state between an ordinary maturing nymph and a true pupa. Thrips are found on plants, usually in flowers and often in great abundance. Some are found only on leaves and they may cause damage to plants by lacerating the epidermal tissues and gradually destroying the leaves. Others are found only in flowers and it is surmised that they feed upon pollen. In Australia some are found causing galls. A large number are also found under bark and in turf. Thrips are commonly reckoned among injurious insects and *Physopus rubrocincta*, Giard, is a serious pest to cocoa in the West Indies, to which place it was probably introduced from Ceylon; others are injurious to cereals, etc., in Europe. Two cases have been seen in India of very slight injury to plants by thrips, and we believe these insects are commonly harmless. The species attacking tea in Sikkim are of greater importance and have in recent years done much damage.

Uzel observes that, while in some species both sexes occur, in some there are only a small number of males, the majority of the females reproducing parthenogenetically: in others, there is one sexual generation yearly, while in a number, no males have yet been found. He also notices that in some species normally wingless, winged females or winged forms of both sexes appear occasionally, for the purpose of spreading the species to new spots.

The monograph of this order by Uzel is written in Bohemian (with a German synopsis) and mentions three Indian species out of 135 then known (1895). He divides the order as follows:-

I. Female with an ovipositor. Wings with two internal and one marginal vein. (*Terebrantia*).

1. Antennæ nine-jointed. Ovipositor curved upwards. *Æolothripidæ*.

2. Antennæ six to eight-jointed. Ovipositor curved downwards. *Thripidæ*.

II. Female without ovipositor. Wings veinless or with one short internal vein. Antennæ eight-jointed. Body flattened, apex of abdomen tubular. (*Tubulifera*) *Phlœothripidæ*.

The recorded Indian species are members of the last family; *Idolothrips halidayi*, Newm. and (?) *Phlœothrips anacardii*, Newm., were described from specimens found on Anacardium in Mysore, while (?) *Phlœothrips stenomelas*, Newm., was found in Ceylon. The species described as *Physopus rubrocinctus*, Giard., also occurs in Ceylon and belongs to the *Thripidæ*, as do the tea thrips.

Very little is known of thrips in India, though they occur commonly. We have two species which are destructive to pulse crops, but they have been found only once. Another is known to attack opium, a fourth is recorded as attacking turmeric in Madras. (Indian Mus. Notes, I, p. 109.)

At least one species is common in flowers, the flowers of Sann Hemp (*Crotalaria juncea*), being commonly full of a harmless thrips. Others have recently been destructive to tea in Darjeeling and other larger forms have been found. There is probably a considerable number of species which require collecting and observing. Specimens should be preserved in spirit, as they are useless dry, unless exceptionally large.

PLATE LVIII.—EXTERNAL ANATOMY OF A FLY.

Fig. 1. **Vertex.**

„ 2. **Front.**

„ 3. **Fronto-orbital bristles.**

„ 4. **Vibrissa.**

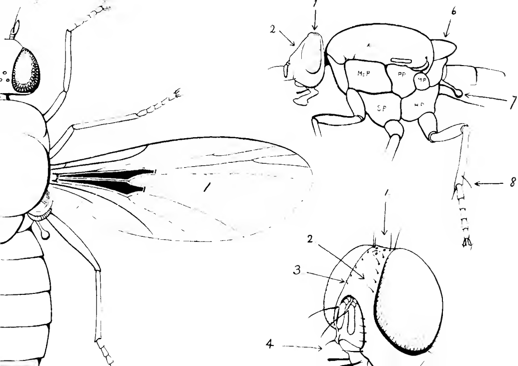
„ 5. **Palpi.**

„ 6. **Scutellum**; the part lying below this is the Mesonotum

„ 7. **Haltere.**

„ 8. **Pre-apical bristle.**

In the left-hand figure the veins of the wing are marked thus: the **Costa, Sub-costa,** Cross-veins, Anal veins, and the two Basal cells are black. The four Posterior cells are lightly dotted. The Radius and its branches are red, the **Media** green, and the Cubitus blue.


M₂P
PP
MP
SP
HP

DIPTERA.—(Flies.)

By F. M. Howlett.

The antennæ moderately long and many-jointed, or quite short with few joints of which the last is thick and bears a bristle-like process. The mouth-parts for sucking, sometimes for piercing also. One pair of wings (mesothoracic), hyaline, with few cross-veins, occasionally hairy or scaly. A pair of metathoracic halteres. The body bristly, hairy, scaly, or bare. The metamorphosis complete; the pupa may be bare with the limbs free, or may be enclosed within the last larval skin. The length of the imaginal life is often greater than the larval, the latter frequently very short. None of the Diptera are very large, and many are very small. None are truly social. The larvæ are without feet; a large number are parasitic on insects and a few on mammals; very many others are scavengers, while some are predators and herbivores; many are aquatic. The adults include very many flower-haunting species and some predators and blood-suckers.

The Diptera are separated into two big groups corresponding to the way in which the pupa or pupa-case splits when the adult insect emerges.

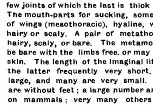


Fig. 348—Split pupa-case.

Those families in which there is a split more or less straight down the back of the thorax are grouped together as ORTHORHAPHA (*i.e.*, "straightcrack"), while those in which the split runs round the end of the pupa-case (fig. 348) are called CYCLORHAPHA (*i. e.*, "roundcrack").

Of course it is often impossible to see the way in which any particular fly escapes from the pupa, and these divisions would be useless were they not also indicated by other characters more easily observed. The Orthorhaphous pupa itself differs from the Cyclorhaphous in that the latter is enclosed in the last larval skin, which remains surrounding it as a protecting case, the pupa and its case together being called a "puparium." In the Orthorhapha, with few exceptions (*e.g.*, the family *Stratiomyidæ*), we find, on the other hand, that the last larval skin is completely shed and cast aside, leaving the pupa bare and unprotected; in such pupæ the limbs and general shape of the future imago can be seen, while in the Cyclorhaphous puparium all these details are completely concealed by the hardened and contracted larval skin which encloses the true pupa. This difference in the type of pupa is associated with a difference in the way the fly gets out of it: in the Orthorhapha the splitting of the comparatively weak pupa-skin is effected by what we may call "hunching the shoulders," and the top of the thorax is the part of the fly's body which is first exposed. The Cyclorhapha employ a different method, perhaps owing to the less yielding nature of the hardened skin which surrounds the true pupa. In order to escape, the fly, instead of trying to crack this skin along the thorax, pushes out the end of it and emerges head foremost. To push out the end it cannot use its feet and limbs, since these are confined mummy-like in the puparium, but it gets over the difficulty by the help of a very remarkable structure, in the shape of an expansible balloon arising from the head. When inflated with liquid from the body, this balloon (called a "*ptilinum*") pushes off the end of the puparium and releases the fly, whose escape is rendered easier from the shrinking of the body due to the absence therefrom of the liquid used to inflate the balloon. (Figs. 349, 350.) The ptilinum is afterwards deflated and disappears into the head, leaving the scar called the "frontal suture" as evidence of its existence (fig. 407). All flies with this frontal suture are Cyclorhapha.

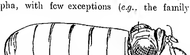


Fig. 349—A FRUIT-FLY (DACUS) EMERGING FROM PUPARIUM. (FROM LIFE.)

It should be noted that three families (*Platypezidæ*, *Pipunculidæ* and the big family *Syrphidæ*) are included in the Cyclorhapha although they do not possess a frontal suture: they are therefore known as Cyclorhapha "Aschiza" (*i.e.*, without suture), being classed with the Cyclorhapha because of the mode of splitting of the pupa-case as well as by the form of the antennæ and by their possessing a small but systematically important structure in the shape of a minute sclerite just above the base of the antennæ, called the *frontal lunule* (fig. 405) which is characteristic of *all* the Cyclorhapha. Apart from these three families the rest of the Cyclorhapha consists of a vast number of species possessing both lunule and suture, and hence known as Cyclorhapha "Schizophora" (*i.e.*, "possessing suture"). House-flies and blue bottles belong to this group. The Cyclorhapha as a whole are also distinguished by their antennæ having not more than three joints, the third joint showing no signs of being segmented or made up of more than one piece, while it bears on its upper side an "arista" (fig. 351) which is quite thin and hair-like and frequently plumose or pubescent. The palpi are unjointed. The Cyclorhapha are thus divided into two groups, the Aschiza and Schizophora. The Orthorhapha are likewise divided, but here the division is based mainly on the structure of the antennæ. The first group, the Orthorhapha "Nemocera" (*i.e.*, "thread horn"), generally have 4-jointed palpi and long antennæ usually composed of a dozen or more similar freely-jointed segments, while the second group, the Orthorhapha Brachycera (*i.e.*, "short-horn") have palpi of not more than two joints, and short antennæ which show various grades between the many-jointed Nemocerous antennæ such as that of mosquitos or *Simulium* (fig. 351) and the simple short three-jointed antennæ of the Cyclorhapha. From the Cyclorhaphous antennæ those of the Orthorhapha Brachycera differ in that they usually show pretty clearly that what

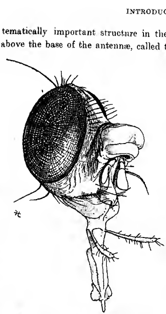


Fig. 350.—HEAD OF MUSCID (CYCLORHAPHA) JUST EMERGED FROM PUPARIUM, SHOWING ABOVE THE ANTENNÆ THE HALF-DEFLATED "PTILINUM."

may look like the third joint and its continuation (arista) is really made up of several joints or segments joined together. It may be noted that when, as in many Brachycera, the "arista" is thick and terminal, it is generally called a "style." to distinguish it from the very thin usually dorsal arista of the Cyclorhapha.

Putting what has been said above into tabular form, we have—

Orthorhapha, with pupa generally free, the fly emerging by a split along the top of the thorax.	(1) *Nemocera* including mosquitos, gnats and the like, with many-jointed antennæ and four or five-jointed palpi. (2) *Brachycera* including the big horse flies ("Dans") and a variety of others, with palpi of not more than two joints and antennæ of various forms intermediate between Nemocera and Aschiza, but generally showing at least traces of more than three joints or segments.
Cyclorhapha, with pupa enclosed in last larval skin, the end of this being burst open by the fly on emerging.	(3) *Aschiza* including many hovering flower-flies, with frontal lunule but without frontal suture. Antennæ simple, 3-jointed with arista. Palpi unjointed. (4) *Schizophora* including house-flies, bluebottles, etc., with lunule and suture. Antennæ simple, 3-jointed with arista, as in Aschiza. Palpi unjointed.

To these we will now add two more groups, whose members can generally be recognized without difficulty.

(5) *Pupipara* including the well-known crab-like dog-flies. Parasitic sometimes wingless insects of curious shapes, flattened, with leathery skin. They lay no eggs, but

produce their young as larvæ or pupæ.

(6) *Siphonaptera*, Fleas. Parasitic wingless jumping insects with narrow flat-sided bodies and leathery skin.

These two groups are so much modified in accordance with their parasitic mode of life that they are easily distinguished from other Diptera, and we shall at present consider only the first four. The classification of these given above depends on the structure of antennæ, palpi, and head, but there is another character, the venation, which is of considerable importance (See p. 553).

The life-histories, while very various in detail, exhibit a general broad similarity. The larvæ in the Nemocera are mostly aquatic or inhabit wet places, the former usually developing into floating pupæ. Very few of the larvæ are predaceous, most of them being vegetarians or scavengers, and the imagos are in many cases blood-suckers (Mosquitos, Midges, Sandflies, and *Simulium*). One family, the *Cecidomyiidæ*, includes many gall-makers. The larvæ of the Brachycera are only occasionally semi-aquatic or aquatic (*e.g.*, *Tabanidæ*, the horse-flies, and *Stratiomyidæ*) and are mostly either predaceous or parasitic on other insects; a few are scavengers. The adult Tabanids suck the blood of animals; several other families suck the juices of insects, while those flies which develop from parasitic larvæ generally frequent flowers and suck nectar.

In both the Nemocera and Brachycera most of the larvæ have a distinct and well-formed head which is clearly separate from the thoracic segments.

The larvæ of Aschiza and Schizophora are of a different type, for in these the head is very small and either habitually retracted or poorly developed, without any neck or distinctly marked division from the thorax, while the jaws are generally represented by two small hooks which work up and down, and not horizontally as in many Nemocera. With the exception of some *Syrphidæ* we do not know of any predaceous larvæ in these groups: a few are aquatic, a considerable number attack living plants, and a still larger proportion are scavengers or are parasitic on insects or mammals.

Excluding the aquatic and some of the parasitic forms, the general appearance of the larva is much the same in the great majority of the species. The tail end is thick and blunt, bearing two chitinized patches marking the openings of the posterior spiracles: from the tail the body tapers toward the head, which is quite small, eyeless, and furnished with a pair of downward-curving hooklets which serve as jaws. The adults are nearly all flower-flies; a few are predaceous and there are a small number of species which suck blood.

If we except the Fleas, Mosquitos, Sand-flies, and perhaps some Midges, we may say that no Diptera appear to be nocturnal. Excepting the predators and blood-suckers, the adults frequent either flowers or filth. Hibernation where it occurs apparently takes place most often either in the larval or pupal condition, but sufficient information on this point has not yet been accumulated, and some flies (*e.g.*, Mosquitos)

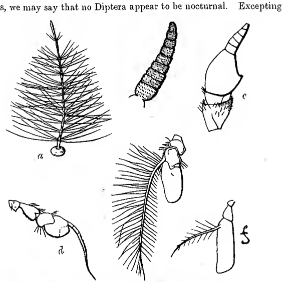


Fig. 351—Antenna of (*a*) Culicid, (*b*) Simuliid, (*c*) Tabanid, (*d*) Dolichopid, (*e*) Syrphid, (*f*) Muscid showing different degrees of shortening and compactness.
(*After Comstock and Sharp.*)

are known to hibernate as adults. Not much is known about the past history of Diptera, but from the study of insects preserved in amber it appears that the oldest forms are among the Nemocera, and that the Schizophora are of much more recent development. Now if we compare these two groups we shall see that development has largely taken the forms of reduction, shortening and simplification of parts, rather than the production of new ones. This does not apply to the ptilinum, which is an organ not possessed by any of the Nemocera, but it does apply especially to the antennæ, palpi, and venation. Fig. 351 represents two antennæ of Nemocera, two of Brachycera, and one of Aschiza and Schizophora. The possible course of development is clearly seen whereby a nemocerous antenna might in course of time be modified into the compact three-jointed Muscid pattern (*f*).

So also with the maxillary palpi (labial palpi are very rarely if ever present): those of the Nemocera generally have four joints, the Brachycera two or one, the Aschiza and Schizophora always one only.

The question of venation is more complex (p. 553), but on comparing the wings of the Nemocera, Brachycera, Aschiza, and Schizophora, it is clear that the main characteristic of the Schizophora is the comparatively few veins in the hinder part of the wing and the closing up of the cells near the base (basals and anal). In the Nemocera the hind part of the wing has several veins, and the anal cell is large and open. In the Brachycera the anal cell shows signs of diminution, and may be either narrowed at the margin or closed. In the Aschiza it is always closed, though often large, while in the Schizophora it is always closed and usually quite small. In this connection it should be pointed out that though what has just been said is true on the whole, yet indications of this line of development by reduction of wing-veins can also be traced in each of the four groups taken singly, more particularly among some of the smaller Nemocera and Brachycera: such are the *Chironomidæ*, some *Bibionidæ* and especially *Simulium* in the former group, and in the latter some *Stratiomyidæ*, *Cyrtidæ*, *Dolichopodidæ*, and especially *Phoridæ*. The same tendency towards simplification is met with in the larvæ. Speaking in a general way one may say that the oldest families of flies are probably those which have aquatic or semi-aquatic larvæ with distinct head and eyes. Such larvæ are the rule among the Nemocera. Bibionid and Mycetophilid larvæ, though not aquatic, cannot endure drought. The gall-making *Cecidomyiidæ* are a much specialised family whose larvæ are in no way aquatic.

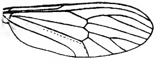
In the Brachycera there are a good number of this aquatic or semi-aquatic type among the more primitive families (*Leptidæ*, *Stratiomyidæ* and *Tabanidæ*), but most Brachycerous larvæ (*Asilidæ*, *Therevidæ*, etc.), live on land, preying on such insects as are found in rather damp but not very wet places such as rotting wood, bark, or in moss or earth: they are active, with distinct heads, the eyes are present in some species and absent in others, and the antennæ are not so well developed as in Nemocerous larvæ. There also occur in this group a large number of parasitic larvæ (*Bombyliidæ*), but these, at any rate in their later stages, are almost incapable of motion and have no distinct head, jaws, eyes or antennæ, though when newly-hatched the larvæ may be very active. Among the Aschiza there is a considerable variety in the form and habits of the larvæ; they may be scavengers, vegetarian, predaceous, parasitic or commensal, and there are a small number which are aquatic [*e.g.*, genus *Eristalis* in family *Syrphidæ* (fig. 404)], but in spite of this variety in their mode of life the head is never well developed, and the eyes and antennæ are either absent altogether or extremely small, the general shape approaching that of a "maggot." Much the same may be said of the larvæ of Schizophora, but in this group there is less variety in habit. In the section containing what are probably the older and less recently developed families (the "acalyptrate muscoids"), there are a few aquatic larvæ (*e.g.*, *Ephydridæ*, *Sciomyzidæ*); and of the rest very few if any are truly predaceous, and almost all feed on living plants or are scavengers or parasites. Simplification of form has here been carried to an extreme (Pl. LXVI, & figs. 424, 425), the head and sense-organs being reduced to the lowest possible point. The probable reason of this extreme simplification lies in the shelter and protection which the larval habits ensure: living as these larvæ do, either inside plants, under dung and decaying matter, or as parasites in the bodies of insects and other animals, they have little need of any organs except those which enable them to eat, breathe and digest; all else has tended to degenerate and disappear, leaving as residue the typical maggot, a creature admirably adapted to succeed in its own simple way of life.

A word should be said here about the breathing arrangements of Dipterous larvæ and pupæ. The devices and structures which they

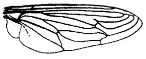
PLATE LIX.

Typical wings of various families of Diptera.
Mostly copied from Comstock and Williston.

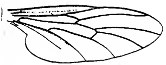
PLATE LIX.



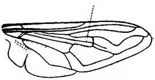
DIXIDÆ.



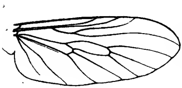
MYDAIDÆ.



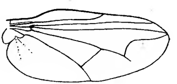
BIBIONIDÆ (*Bibio.*)



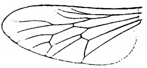
SYRPHIDÆ (*Eristalis.*)
(The dotted line indicated the " False Vein.")



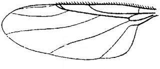
RHYPHIDÆ.



DOLICHOPIDÆ.



LEPTIDÆ.



PHORIDÆ.

employ to obtain oxygen are extremely beautiful, but so various that we cannot attempt any general account of them; the student will find a great deal of interesting information in Miall's "Aquatic Insects," and further knowledge can be obtained from the nearest tank.

The typical respiratory system of the Dipterous larva consists of two big tracheal tubes running from tail to thorax, connected with each other by cross-tubes and having side branches to the lateral spiracles. There is a general tendency for these lateral spiracles to degenerate, so that breathing may be mainly or entirely carried on by the anterior (prothoracic) and posterior spiracles only; larvæ with this arrangement are called "amphipneustic;" in many larvæ, especially in aquatic species, the posterior spiracles alone remain functional, and then the larvæ are called "metapneustic." In these aquatic forms respiration is often carried on in part by gill-processes, generally situated at the tail end of the body (see p. 131).

Some parasitic larvæ (*Oestridæ*) are able to live for long periods in the body of their victim without any air.

Venation.—The nomenclature of the wing "veins" or "nervures" has for long been a source of confusion to the student, since there is no one authoritative system in vogue. The most satisfactory is that of Comstock and Needham, a modified form of which we have therefore adopted. Comstock's system is based on an extensive comparative study of the development of the veins in the wings of a large number of insects, and is applicable to other orders besides Diptera. To explain it, we will take as an example one of the common large horse-flies (*Tabanus*), shown on Pl. LXII (*not* the well-known flat brown cattle and dog-flies). Forming the front edge of the wing is a strong vein called the *Costa*, which in this case is continued right round the edge of the wing. Just behind it is the *subcosta*, which joins it about half-way along the front edge of the wing. Just near the base of the wing the *costa* and *subcosta* are connected by a short cross-vein, the *humeral cross-vein*. Behind the *subcosta* is a third vein, which is seen to be single near the base of the wing, but branches towards the tip into four separate veins. This vein is called the *Radius*, with its branches, first, second, third and fourth (counted from the front). Behind the radius, and connected with it by a little cross-vein in the middle of the wing (the *anterior cross-vein*), is the *Media*, which divides near the middle of the wing into an anterior and a posterior branch, the anterior branch having an offshoot (coming off nearer the edge of the wing) connected with the posterior branch by a small cross-vein (the *posterior cross-vein*), and thus completely enclosing a small space in the middle of the wing. This enclosed area is called the *Discal cell*. Looking again at the basal half of the wing, we see behind the *Media* a vein called the *Cubitus*, dividing, like the *Media*, into two branches, of which the front one is joined by a little cross-vein to the posterior branch of the *Media*. The other (posterior) branch of the *Cubitus* coälesces, before it reaches the edge of the wing, with the *anal*, the sixth and last longitudinal vein.

In speaking of the spaces bounded by veins, *i.e.*, the *cells*, we use the following names. The cell between the costa and subcosta is the *Costal* cell, that between the subcosta and radius, the *subcostal*. Separating the main stem of the radius from that of the media is the *first basal* (bounded on the outermost side by the anterior cross-vein), while the *second basal* similarly separates the media from the cubitus. The cell between the cubitus 2 and anal vein is the *anal* cell, which in this case is closed before the margin of the wing is reached owing to the coälescence of the cubitus 2 and anal veins. The cell behind the anal vein is the *axillary*.

Taking now the cells bordering on the outer edge of the wing, the one lying next to the subcostal cell on its outer side is the *marginal cell*

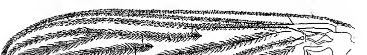


FIG. 352—ANOPHELES WING, AFTER NUTTALL AND SHIPLEY. THE CROSSES INDICATE THE VEINS MEDIA 1 AND MEDIA 2.

(between the first two branches of the radius). Next behind it is the *1st submarginal*, and behind this and including the point of the wing is the *2nd submarginal*. Along the edge of the wing, filling up the space between the 2nd submarginal cell and the coälesced cubitus 2 + anal vein, five cells can be seen, which are the five *posterior cells*, the front one being called the first.

On comparing the figure of the mosquito's wing (fig 352), we see that the *media* is only two-branched, and there is no *posterior cross-vein*, and thus no closed *discal cell*. Also the *cubitus* 2 and *anal* veins do not coälesce, but remain quite separate, leaving the *anal cell* open at the margin of the wing.

The house-fly type of wing (fig. 423 & Pl. LXVIII) has diverged a good deal from that exhibited by the horse-fly and mosquito. This is thought to be due to the coälescence, or growing together inwards from the margin, of certain veins at some period in the past history of house-flies, and a consequent reduction in the number of veins apparently present.

There is only one *submarginal cell* (*i.e.*, the radius is 3—instead of 4-branched). The media is 2-branched, the first branch turning up so as nearly to close the *first posterior cell*. The branching of the *media* occurs quite near the base of the wing, and the *posterior cross-vein* is rather near the margin, so that the *discal cell* is large. The posterior branch of the *media* has coälesced along nearly its whole length with the anterior branch of the *cubitus*, while the short posterior branch of the latter joins the *anal vein* near the base of the wing, the *anal cell* being thus quite short (*i.e.*, "closed remote from the margin"). Just behind the *anal vein* is a small *second anal vein*. There is another system of naming the veins which is very often used, and which is more convenient when dealing with the specialized wings of most Cyclorhapha: we therefore give it for comparison and reference. The names of the cells and cross-veins are the same: the others as follows:—

Costa		Costa.
Subcosta		Auxiliary.
Radius	1	1st Longitudinal.
,,	2	2nd Longitudinal.
,,	3	3rd Longitudinal anterior branch.
,,	4	3rd Longitudinal posterior branch.
Media	1	4th Longitudinal anterior branch.
,,	2	4th Longitudinal posterior branch.
,,	3	5th Longitudinal anterior branch.
Cubitus	1	5th Longitudinal posterior branch.

Cubitus	2 ..	Posterior basal cross-vein.
Anal	.. ..	6th Longitudinal.

Some of the terms here used in describing flies may need explanation.

Squamæ (fig. 353), are small membranous flaps covering the little knobbed rods called *halteres* at the base of the wing. The part of the head between the eyes and above the antennæ is called the *front*, and rows of bristles down its sides are called the *fronto-orbital bristles* (Pl. LVIII). A large single bristle on the tibiæ some little way above its lower end is called a *pre-apical bristle.* On the feet the two outer pads are called the *pulvilli*, the middle one the *empodium.*

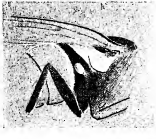


Fig 353—SQUAMÆ OF A BLUEBOTTLE, SEEN FROM THE SIDE AS TWO WHITISH FLAPS COVERING THE HALTERE; THE OVAL HEAD OF THE LATTER IS SHOWN IN THE CENTRE OF THE FIGURE.

The study of Indian Diptera has until quite recently been much neglected. With the exception of a small amount of information contained in Indian Museum Notes, practically no record of work on the habits and life-histories of any but the *Culicidæ* has been found. In this latter family the student will be greatly helped by Giles' "Mosquitos", James and Liston's "Anopheles of India," the latter with excellent plates, and Theobald's "Monograph of the Culicidæ," together with other more scattered literature. Dr. Speiser's writings on Pupipara contain many references to Asiatic species, and those parts of "Genera Insectorum," which refer to Diptera will be found useful when they are available for reference. For the rest, Van der Wulp's "Catalogue of the Diptera of S. Asia" (up to 1896) is essential, and will form the basis of all future work. In it will be found references to former literature and to the original descriptions of a large number of Asiatic species. As a really general text-book in English does not yet exist, a beginner would probably do best with the just published edition of Williston's excellent "N. American Diptera," remembering that it treats only of American species. The Indian Museum is at present publishing in the Museum Records the results of a revision of the species in the Calcutta collection, and these will be extremely useful to students of the systematic side of the subject. Since any lists of species at present known would so very soon be useless in view of the rapid expansion of our knowledge of Indian flies, we have written this section with the object of giving merely a general introduction to their study and some slight idea of their habits.

ORTHORHAPHA NEMOCERA.

PSYCHODIDÆ.

Very small hairy moth-like flies. Wings broad and hairy, meeting roof-like over the body as in moths, except in Phlebotominæ. Ten longitudinal veins, without the usual cross-veins. Wings often clothed with scales.

These curious little flies are often seen in shady rather damp places on tree-trunks or bath-room windows. They often run nimbly about in little circles, but their flight is feeble. Their venation is remarkable owing to the absence of any cross-veins, except near the base of the wing. The larvæ (fig. 356), generally live in wet or rotting vegetable stuff but some are more purely aquatic, with a short breathing tube at the tail, while in some species (*Pericoma*), there are a pair of anterior spiracles as well as a posterior pair, the latter opening into a fringed cup rather similar to that possessed by Culicids, Stratiomyiids, and several other aquatic larvæ. This presence of functional anterior spiracles is a rare condition among aquatic larvæ.

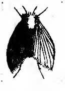


Fig. 354—PSYCHODA × 8.

Some larvæ of Psychodids (fig. 355), found in Brazil, in company with those of *Blepharoceridæ*, on rocks about waterfalls, show a curiously similar adaptation to life in swiftly running water.

The normal Psychodid pupa (fig. 357) is in general appearance a good deal like that of Lepidoptera, with the addition of a pair of anterior horns through which it breathes while floating in the water or lying in damp soil or decayed vegetable matter.

There are very few genera in this family, but a considerable number of species, between fifty and a hundred being known in England. Few are yet recorded from India (Ind. Mus. Rec., Annandale and Brunetti) but an examination of the walls and windows of bath-rooms soon shows that the insects are abundant in the plains as well as the hills. Two species are very common at Pusa (fig. 356). the larvæ of both being aquatic or semi-aquatic, living in places where water constantly drips, or in holes in tree-stumps and similar spots, and feeding on green algæ and other vegetable matter. The two largest genera are *Psychoda*, in which the last branch of the Radius ends at or in front of the wing-tip, and *Pericoma* in which it ends behind it.

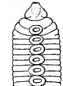


Fig. 355—LARVA OF A BRAZILIAN PSYCHODID (AFTER MULLER), ENLARGED.

Dr. Annandale has made the interesting discovery that *Diplonema*, a genus hitherto known only from specimens found in amber, occurs in the Himalayan region.

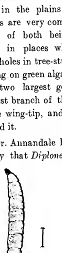


Fig. 356—NEARLY FULL-GROWN LARVA OF PSYCHODA BENGALENSIS, PUSA.

The chief importance of the family depends on the fact that some few species are vigorous blood-suckers. Until comparatively recently the identity of these flies in India was apparently hardly recognised, though one species had been described from Ceylon, but in reality these *Psychodidæ*, belonging to the genus *Phlebotomus*, form the bulk of those annoying insects which are known as "Sand-flies" and universally condemned. Specimens have been taken from a variety of localities from Calcutta to the Punjab and Bombay, and they are also widely distributed through South India (N. Annandale). The females alone bite. Their small size gives them an advantage over Mosquitos, since they are able to walk through an ordinary mosquito-net without difficulty. The ankles are a favourite point of attack, and the flies will even sometimes crawl under the bed-clothes in their lust for blood. I find their bite peculiarly irritating, much more so than that of the common mosquito (*Culex fatigans*), and it produces a small red swelling which may persist for some days. They are very partial to babies. I have hitherto found a mixture of some kerosene with Hazeline or Lanoline cream, the only really good preventive, but moderately thin socks will protect the ankles. The flies are found in much the same localities as other Psychodids, especially in bathrooms (generally in shady corners near the floor), in latrines, under piles of damp bricks or stones, and in similar damp shady places during the day. They are fond of hiding behind shutters on the verandah, and at night they emerge from their seclusion to bite. They differ from other Psychodids in their attitude, the wings being carried divergent, pointing backwards and upwards (fig. 358). The sexes are distinguished by the large and complex genital clasping-apparatus of the male (fig. 359), the termination of the female abdomen being without any such conspicuous structures and comparatively simple. Copulation generally seems to take place at night. The eggs are laid singly or in small clusters, and number from about 30—80 in different species observed. The larvæ are found in damp earth, and are very curious; they have a large well-marked head with big jaws; the body is covered with toothed spines, perhaps as a protection from enemies (similar spines also occur in some other Psychodid larvæ), and the

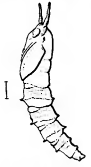


Fig. 357—Pupa of Psychoda bengalensis, Bru. Pusa.

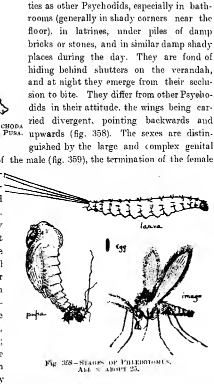


Fig. 358—Stages of Phlebotomus. All × about 25.

posterior end of the body is furnished with some processes and bristles, two pairs of which in the full-grown larva are as long as the body and head together. The pupa, found on the damp earth, is also remarkable for the large ridges and excrescences on the thorax. The egg, larva, pupa, and imago are shown in fig. 358. The length of the life-history varies from a month in the hot weather to six to eight weeks or more in the winter at Pusa. Real hibernation has not yet been observed. The eggs are laid usually in wet and dirty places, and hatch in about six days. The larvæ feed on semi-decaying vegetable matter for a fortnight or three weeks, and then pupate, the fly emerging from the pupa in about six to ten days. Some half a dozen species of the genus are known from India; at least two of these seem to be found almost all over the country, but others are more restricted in their range.

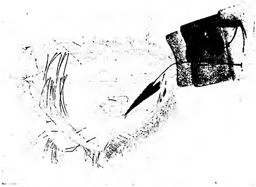


Fig. 359—Male genital clasfers of Phlebotomus. From a photomicrograph.

Chironomidæ. *Gnats, Midges.*

Small mosquito-like flies. Antennæ plumose in the male. Ocelli generally absent. Proboscis short. Wings often hairy but not scaled as in Culicidæ. Costa reaching only to tip of wing.

These flies are very easily confused with mosquitos, but with the exception of one group of genera mentioned below they are entirely inoffensive creatures. They are readily distinguished from the *Culicidæ* by their short proboscis and the absence of scales. In the Mosquitos the hind edge of the wing is fringed with little scales and bordered by the costal vein, while in the Midges there are no scales (though the wing may be hairy), and the costa stops short at the tip. In the Chironomids the veins in the front part of the wing are often much more strongly marked than those behind, just as in the Simuliids, Bibionids, Stratiomyids, Hippoboscids, and Phorids. In their resting attitude they often raise the fore-legs and hold them up in front of the head, while in Mosquitos it is the hind legs which are raised from the ground. They are very frequently observed dancing in small swarms in the still evening air.

A species of "*Ceratopogon*" has been observed at Pusa to settle in a thick swarm of several hundred individuals on the underside of four or five leaves of a Pipal tree, remaining there for four days in spite of a heavy shower of rain. Some of them which were caught and kept soon began pairing, and it is not improbable that all such curious assemblies, as well as aërial dances, have some connection with the sexual relations of the insects which take part in them.

The sexes can, as a rule, be at once distinguished by the antennæ, which are thickly plumose and feathery in the males but not in the females. The male genital claspers can also be easily seen in most cases.

With the exception of the *Ceratopogoninæ*, some of which are bloodsuckers, the *Chironomidæ* are of little practical importance. To the biologist, however, they afford very suitable objects for study, and a good deal of work has been done on their anatomy and development. They are nearly all aquatic. All stages of *Chironomus* and allied genera may be found in tanks and pools of stagnant water. Their eggs are in many cases laid in beautiful little spiral strings, enclosed in a long cylinder of clear antiseptic jelly which is anchored to weeds or stones. The eggs may be very numerous, one of these cylinders sometimes containing nearly 1000. I have observed a small *Chironomus* make the curious mistake of laying its eggs on a pane of glass instead of in water. The jelly cylinder when extruded formed only a quite thin covering to the string of eggs, but when the string was removed from the glass and placed in water, the jelly rapidly expanded to form the usual thick protecting envelope. The stages of a common Indian Chironomid are shown on Plate LX, figs. 3, 3*a*, 3*b*, 3*c*.

The larvæ are worm-shaped, with characteristic leg-like processes on the first and last segments, and swim with a lashing motion. They are sometimes red (the "blood-worms" of the British water-butt) and have gills and real red blood like fish (their tracheal system being then merely rudimentary), or they may be greenish and breathe in the ordinary way by well developed tracheal tubes. Sometimes the larvæ live free, but more usually they inhabit burrows in the mud or live in little tubes constructed of bits of algæ or similar substances. They have occasionally been found living at great depths. The pupæ are active, and are furnished with tufted gills instead of the breathing-horns usually found in aquatic pupæ. They generally occupy the larval tubes, where they lie gently undulating the abdomen so as to create a current of fresh water through the tube. When the fly is ready to emerge, the pupa leaves its shelter and swims to the surface, whereupon the imago escapes from the pupal skin in the same way as a mosquito.

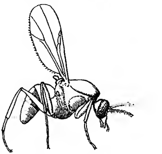


Fig. 360—Ceratopogon sp. Nasik. × 16.

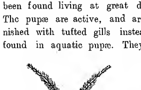


Fig. 361—Ceratopogon sp. Pusa. × 24.

The sub-family *Ceratopogoninæ* is of interest, as it comprises a number of species which are blood-suckers, some of them of a very determined nature. Here belong those "midges" which in England, and especially in Scotland, often cause by their attacks an annoyance out of all proportion to the minute size of the blood-thirsty little flies. They are seldom more than 3 mm. long, of a rather thicker build than other Chironomids, and their small size often enables them to escape unnoticed; fig. 361 represents a species which is known to bite at Pusa. As with several biting flies, the state of the weather and conditions of temperature and moisture seem to have some influence on their appetite for blood, and in Europe they are supposed to bite most freely before rain.

The mode of life of the *Ceratopogoninæ* is somewhat different from that of other Chironomids.

The eggs are not laid in strings, but singly or in small clusters, generally about 30—60 eggs in all. There are two distinct types of larvæ. One kind is aquatic, snake-like and transparent, and lives on the surface of stagnant water or in slow streams. Assisted by a tuft of long bristles at the tail end, they move rapidly with a wriggling motion along the surface and in the water, and develop into dark coloured inactive floating pupæ with breathing-horns on the thorax. These aquatic larvæ are said generally to mature into flies with naked wings, but they do not always do so.

A second and commoner type of Ceratopogonine larva, which is supposed to produce, as a rule, hairy-winged flies, is terrestrial, living in

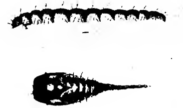


Fig 362.—TERRESTRIAL LARVA AND PUPA OF CERATOPOGON SP. PUSA. THE LARVAL SKIN IS STILL ATTACHED TO THE HIND END OF THE PUPA.

rotten vegetable stuff, under damp bark and similar places. They are caterpillar-like in shape, and have a double foot-like process on the 1st thoracic segment, with a somewhat similar structure on the anal segment, which assist in locomotion. The body is covered with numerous small processes or papillæ, each usually bearing a bristle at the apex, these bristles being often curiously shaped and expanded at the tip. The pupæ are quite distinct in appearance from those of the aquatic species (fig. 362), and are often found with the last larval skin still enveloping the hinder part of the body.

About a thousand species of *Chironomidæ* are known, but of these only four are recorded as Indian, *viz.*: *Chironomus vicarius*, Wlk., *C. socius*, Wlk., *C. cubiculorum*, Dol., and *Macropeza gibbosa*, Wied.; this of course in no way represents the very large number of Indian species which really exist, for of these there must be hundreds.

The following table of the chief sub-families is abridged from that given by Kieffer .—

1. Media and cubitus united by a cross vein ...... *Tanypinæ*.
   Media and cubitus united only at the base .... 2.
2. Thorax humped over the head. Male antennæ with last joint as long or longer than all the preceding joints. Media single (except *Coryoneura*), legs and tarsi long and slender .... *Chironominæ*.
3. Thorax not humped over the head. The last antennal joint never longer than the two preceding. The last 5 joints usually of different shape from the others. Media generally forked, legs and tarsi comparatively stout (except *Macropeza*) .... *Ceratopogoninæ*.

CULICIDÆ.

Mosquitos. Slender flies with the wings and body scaly, long legs and proboscis, and well-developed palpi. Antennæ long, feathery in the male.

Mosquitos are of course familiar to everyone, and are easy to distinguish by their scaly wings and long proboscis. No other flies except *Psychodidæ* have scales on their wings, and the short proboscis of the Psychodids, as well as their general appearance, is quite distinctive. *Chironomidæ*, which are much like mosquitos, have not got a long proboscis.

The scales on the wings, head, and body have frequently characteristic shapes in the different species and genera, and are therefore used in classification.

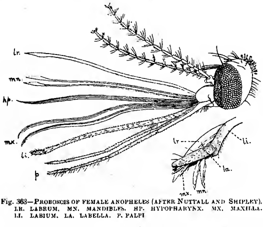


Fig. 363—PROBOSCIS OF FEMALE ANOPHELES (AFTER NUTTALL AND SHIPLEY). LR. LABRUM. MN. MANDIBLES. HP. HYPOPHARYNX. MX. MAXILLA. LI. LABIUM. LA. LABELLA. P. PALPI

As is well known, female mosquitos are blood-suckers, and their proboscis is modified for the purpose (Fig. 363). It consists of a gutter-shaped lower lip (Labium) roofed in by the upper lip (Labrum) so as to form a complete tube, a sheath and support for the inner parts. These consist of a rather flattened blade-like "hypopharynx" and four sharp serrated needles (the two mandibles and maxillæ), and it is these inner parts which do the actual work of piercing and sucking. If a mosquito be carefully watched while biting, it will be seen to begin by planting the tip of the proboscis on the skin. The tip bears two slightly swollen lobes (the labella), and when it is pressed against the skin these lobes spread out on each side, like a man's hands when he leans on a table, so as to give support and steadiness to the proboscis. As the inner needle-like structures are pushed further into the skin between the two steadying lobes, the latter maintain their position at the surface, and in consequence the outer sheath (labium) of the proboscis does not really pierce the skin at all, but can be seen to bend elbow-like so as to allow the labrum and piercing needles to be inserted to a satisfactory depth. The insect injects an irritating saliva into the wound, possibly in order to produce a little local inflammation and so to draw a more plentiful blood-supply to the spot. This saliva passes down from the salivary glands in the thorax through a minute canal inside the hypopharynx, and the hypopharynx also serves, by closing up the under side of the labrum, to form a tube up which the blood is sucked by the pumping action of the front part of the throat. Very soon after feeding the mosquito ejects through the anus a clear yellowish liquid, which is the fluid portion of the blood.

The more solid matter remains in the stomach and is completely digested in one to four days, when the insect is ready to suck again. As

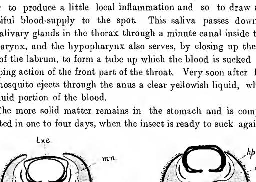


Fig 364. —(After Nuttall and Shipley) Transverse sections of mosquito's proboscis. Lxe, labrum. mn, mandible. mx, maxilla. hp, hypopharynx. sal salivary duct. The large sheath (dotted) is the labium. The right hand figure represents the male proboscis, which has no mandibles. (Compare Tabanidæ.)

is probably the case with all blood-sucking flies. a meal of blood seems to favour the production of eggs, and in some cases is perhaps even a necessary preliminary to successful reproduction. The male mosquito is harmless and generally lives on the juices of plants and fruit.

In pairing, the sexes come together in the course of the aerial dances in which they often indulge, and the actual copulation is in general very short. The males are easily distinguished from the females by their more bushy antennæ and the shape of their genital organs, which include two hook-like claspers, these being plainly visible with the aid of a lens. The female lays her eggs in water. Those of the *Culicinæ* are generally stuck together to form the well-known little raft-like masses, while the *Anophelinæ* lay theirs singly, as also does *Stegomyia*, a Culicine. The eggs themselves vary in shape among the different species, and are often furnished with small floats to keep them at the surface. Several lots of eggs may be laid by the same female. The larvæ emerge from the under side of the eggs and thus go directly into the water. They have a very distinct head and thorax, the head usually bearing eyes. The jaws are provided with a thick fringe of hairs, and their continual motion sweeps towards the mouth the little particles of vegetable or animal matter on which the larvæ feed. Some species are cannibals: these have specially modified jaws to fit the habit, and will often attack and consume Chironomid larvæ considerably larger than themselves. The abdomen is composed of nine segments; the eighth bears gill-processes and the ninth is prolonged upwards in Culicines into a "siphon" or breathing-tube, at whose summit the two big longitudinal tracheæ open. The end of the tube is surrounded by a fringe of fine hairs, and when these are expanded on the surface of the water, they prevent the tube from sinking and the opening of the tracheæ from being submerged. The Culicine larva spends a considerable part of its life thus suspended by its siphon-fringe to the surface-film of the water, but if it is frightened or wishes to feed at the bottom, it can shut up the fringe like an inverted umbrella, and its own weight then causes it to sink. It can swim rapidly with a quick wriggling motion, the many hairs and bristles about the tail acting as a kind of fin.

The larvæ are of two types, those of the Culicine type just described being easily distinguished from Anopheline larvæ by their characteristic attitude when resting, as is also the case with the adult mosquitos of these two groups. The Culicine larva is supported in the water only by the siphon-fringe, while its head and body hang down; the siphon of the Anopheline larva is extremely short, and it possesses in addition a series of branched or tufted hairs ("stellate hairs") along the body. The hairs are shaped rather like little palm-trees, and their branches resting on the surface film of the water support the larva whose body in consequence does not hang down, but lies along horizontally just below the

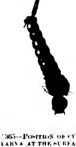


Fig. 365.—Position of Culicine Larva at the Surface. (*After Giles*) × 5.

surface. The larvæ seem to be lighter than those of *Culex*, and their own weight is not sufficient to sink them, so that they are forced

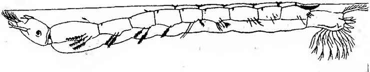


Fig. 366—ANOPHELES LARVA RESTING AT THE SURFACE, PARTLY SUSPENDED BY ITS PALMATE HAIRS. MUCH
(*After Imms.*)

to swim when they wish to leave the surface. Unlike the *Culex* larvæ, they rarely seek the bottom except when frightened. They have the curious habit of often feeding with the head turned completely round on the neck, so that what looks as if it were the top of the head is really the under side. While the Culicine larva thus hangs in the water head downwards, the adult *Culex* mosquito has the body roughly horizontal when at rest, the thorax being the highest point, while the *Anopheles* mosquito (whose larva lies horizontal) sits with the head, thorax, and abdomen in one straight line, the head down and the tail up, as in Fig. 368. (*N.B.*—The female *Myzomyia culicifacies*, an Anopheline, sits like a *Culex*.) When the larvæ pupate, which they do after two or three moults, the whole elaborate breathing apparatus at the tail end disappears, and its place is taken by two trumpet-shaped spiracles projecting from the thorax which supply air to the tracheæ when the pupa is

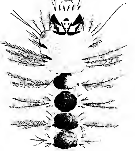


Fig. 367—HEAD AND THORAX OF AN ANOPHELINE LARVA × about 16.
(*After James and Liston.*)

PLATE LX.—NEMOCERA.

Fig. 1. *Pselliophora laeta.* x 2.
,, 2. *Cecidomyia* sp. (Cecidomyiidæ) x 10.
,, 2*a*. } Larva and pupa x 12.
,, 2*b*. }
,, 3. *Chironomus* sp. (Chironomidæ). x 8.
,, 3*a*. String of eggs enclosed in jelly x 3.
,, 3*b*. } Larva and pupa x 5.
,, 3*c*. }
,, 4. *Myzomyia* (Anopheles) *Rossii*, Giles. x 5.
,, 5. *Stegomyia scutellaris*, Wlk. x 5.
,, 6. *Culex fatigans*, Wd. x 5.

Figures 4, 5, and 6 are copied from Theobald's "Monograph of the *Culicidæ.*"

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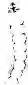

2a

2b

2

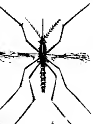
3b

3c

3a

3

4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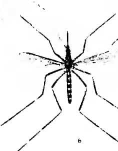
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floating at the surface. The pupa itself is shaped like a comma (,), a swollen rounded mass containing the head, thorax, legs and wings, with the abdomen curved round underneath. The tail is furnished with fins or paddles like those on the tail of a lobster, and by means of these the pupa can swim downwards very quickly when disturbed. It is lighter than water, and floats at once to the surface unless it continues to work its tail-paddles. There are no very marked differences between Anopheline and Culicine pupæ, but the resting position is usually not quite the same, the Culex pupa often floating with the head higher and the first few segments of the abdomen more nearly vertical than in the pupæ of Anophelines. The structure of the spiracular trumpets is also rather different in the various species, and the aperture is more slit-like in Culex than in Anophelines. When the adult mosquito is ready to emerge, the pupa straightens out and lies flat along the surface, the empty skin forming a convenient raft for the mosquito to stand on while its wings and body dry and harden.

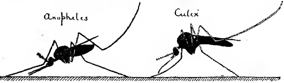

Fig. 368.—USUAL RESTING ATTITUDE OF "ANOPHELINES" AND "CULICINES." (*After Manson.*)

The habits of Indian *Culicidæ* are various, some being "domestic" species frequenting houses, while others are found only in jungle and other such places. Their seasonal distribution is an important subject on which information is much needed, since every locality appears to have a more or less well-marked yearly cycle of species, different mosquitos being common in the cold weather, hot weather, and rains.

The reason why the study of the habits of *Culicidæ* is so important lies of course in the great discovery that it is through their bites that **Malaria** and **Filariasis**, with some other diseases, are transmitted from man to man. Though it is possible that other factors may also be of importance there is now no doubt that malaria, the real curse of India, is thus transmitted. Those interested in the question of the influence of malaria on the inhabitants of a country should consult "Malaria" by Jones, Ross, and Ellett.

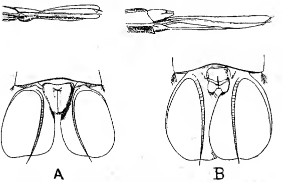

Fig. 369—A. TAIL OF PUPA OF FEMALE ANOPHELES. B. OF MALE. (*After Nuttall and Shipley.*)

The malaria infection by mosquito-bite occurs roughly as follows. Suppose a man is suffering from the disease: if a drop of his blood be examined under a microscope, there may be found floating about in it a number of minute objects called "Crescents." (Fig. 370. C). Now, suppose a mosquito bites him: it will suck up with the blood some of these crescents; these will be swallowed by the mosquito, and when they reach the insect's stomach they become round in shape, some of them producing long rapidly-moving arms or filaments from their surface. Of these round-shaped bodies the ones with filaments (Fig. 370. M.). represent males, the others females. Some of the lashing filaments break off, and may pierce and become absorbed in one of the female bodies: this now fertilized female body imbeds itself in the muscles surrounding the mosquito's stomach, where on dissection it can be seen sticking out like a little round pimple. There now develop within it a vast number of very minute spindle-shaped "sporozoites:" the wall of the containing female cell then bursts, and these sporozoites are liberated into the body of the mosquito, whereupon they make their way to the thorax and enter the salivary glands. If now the mosquito bites anyone, saliva will be injected into the wound, as already described, and with this saliva will pass some of the sporozoites, which will thus be introduced into the blood of the person bitten. Once there, they enter

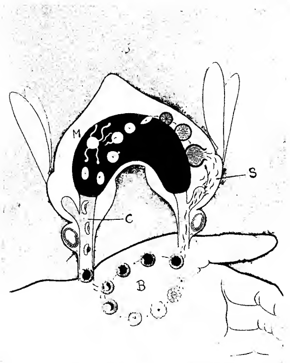

Fig 370.—Diagram showing the two ways in which the malaria parasite multiplies. B shows the asexual cycle in the blood-corpuscles of man. On the left side are shown crescents (at C) being sucked up by a mosquito. These develop into male and female (at M) in the mosquito's stomach (shaded black). The fertilised female encysts on the stomach wall, and from her burst forth a family of sporozoites (at S) which settle in the mosquito's salivary gland (shown by the large arrow). If the mosquito now bites someone else, these sporozoites, injected with its saliva, enter the blood-corpuscles of the person bitten. Here they grow, and while some pursue the cycle B, some may become crescents and be sucked up by another mosquito to go through the sexual cycle in its body.

the blood-corpuscles, whose interior they slowly absorb, and when full grown they either break up again to form a fresh lot of minute bodies which will enter a fresh lot of blood-corpuscles (this breaking up being the cause of the shivering or "rigor" stage of the disease), or else they develop into crescents which float about free in the blood: these crescents may of course be sucked up by another mosquito and the cycle carried through again. Thus we see that the parasite multiplies *in two ways;* sexually in the mosquito, and asexually (by simply splitting up into small fragments) in our blood.

It is not all mosquitos which are capable of harbouring the malaria parasite and allowing it to develop in their stomachs, but only some of those belonging to the *Anophelinæ.* Manson ("Tropical Diseases") enumerates eleven Indian species as having (up to 1907) been shown to be probable carriers of the parasite, and these belong to the genera *Myzomyia*, *Pyretophorus*, *Myzorhynchus*, and *Nyssorhynchus*, all of which are really sub-genera of the old genus "*Anopheles*." *Myzomyia Rossii*, the commonest Indian Anopheline, but not a malaria-carrier, is figured on Pl. LX, fig. 4, where are also shown two other mosquitos both important Culicines. One is *Stegomyia fasciata*, which with *S. scutellaris* is not uncommon in India, the latter species being abundant. *S. fasciata* is the recognised transmitter of yellow fever, and is suspected with regard to several diseases, while *Culex fatigans* (Pl. LX, fig. 6) is the commonest Indian brown Culicine mosquito, and is known to carry the parasite which causes elephantiasis (*filariasis*) so prevalent in Southern India.

It is clear that to avoid whenever possible the bites of all mosquitos is a sensible and obvious precaution. It is not only unpleasant but stupid to sleep without a mosquito-net in malarial districts where mosquitos are present. A net with a hole in it is useless. When no mosquito-net is available, as in railway carriages, a small quantity of Citronella (Lemon-grass) oil rubbed on the exposed parts of the body is effective for four or five hours unless the user is perspiring freely, when it more quickly loses its efficacy. Turpentine or kerosene ointment are effective but unpleasant.

For destroying mosquitos, the remedy usually advocated is the application of kerosene to the surface of the water in which they breed, so as to choke the tracheæ of the larvæ and so suffocate them. Indian conditions often render this a difficult or impossible method to carry out, and the stocking of all suitable waters with such fish as will eat the larvæ (of these there are several in India) has been recommended as likely to be beneficial. In jungle districts nothing can be done without clearing and draining. The value of quinine is well known, and the screening of infected persons from mosquitos is obviously indicated as a preventive measure against spreading malaria. The mosquitos found in houses are mainly nocturnal in their habits, and may often be seen in the early morning trooping into the house in search of dark corners where they can shelter themselves from the light until evening. Lefroy's mosquito-trap takes advantage of this habit by providing a convenient dark box for the mosquitos to rest in: when they have settled down for the day the box is closed and a few drops of benzene or chloroform introduced through a cork-hole in the top. The dead insects are afterwards removed and the box left open till next day.

Much has been written on the subject of mosquitos and disease. The student is referred to Manson's "Tropical Diseases," Blanchard's "Les Moustiques," Stephens and Christophers' "Practical Study of Malaria," Daniel's "Laboratory Studies," and Giles' "Mosquitoes" (2nd Ed.). For the distinction of species James and Liston's "Anopheles of India" and Theobald's "Monograph of the Culicidæ" and Genera Insectorum "Culicidæ." The Journal of the Bombay Nat. Hist. Society and the "Journal of Hygiene" (articles by Liston and others, and by Nuttall and Shipley, Rogers, Imms and others) should be consulted, as well as the large medical literature. The direct identification of the species will sometimes be found easier than the ordinary method of determining the genus first and the species afterwards, since the genera of *Culicidæ* are frequently established on minute scale characters which are sometimes more difficult to see than the characters which separate the species.

The two main Indian sub-families *Anophelinæ* and *Culicinæ*, the latter including *Culex* and *Stegomyia* as chief genera (Stegomyias are generally recognizable by their being coloured black with silver lines and spots and by the characteristic feel of their bite), have the metanotum without hairs or scales. The male palpi are long in both groups, the female palpi long in *Anophelinæ*, short in *Culicinæ*.

I include a list of Theobald's genera now known to me as Indian, with the species in each. The genera down to and including *Aldrichia* represent the "*Anopheles*" of James and Liston: *Corethra* is an aberrant genus with no scales on the wings, a short proboscis and a remarkable transparent aquatic larva (see Miall's "Aquatic Insects"). It is often separated as a distinct family *Corethridæ*.

Anopheles aitkenii, J. & Th.
,, *immaculatus*, Th.
,, *gigasi*, Giles.
,, *lindsayii*, Giles.
Myzomyia culicifacies, Giles.
,, *christophersi*, Th.
,, *Turkhudi*, Liston.
,, *leptomeres* Th.
,, *Rossii*, Giles.
Stethomyia culiciformis, J. & L.
Pyretophorus jeyporensis, James.
,, *nigrofasciatus*, Th.
,, *Nursei*, Th.
,, *elegans*, James.
Myzarhynchus nigerrimus. Giles.
,, *barbirostris*, V. D. W.
,, *minutus*, Th.
,, *vanus*. Wlk.
,, *albotæniatus*, Th.
Nyssorhynchus Stephensi, Liston.
,, *Theobaldi*. Giles.
,, *Indiensis*, Th.
,, *Willmori*. James
,, *Karwari*, James.
,, *Jamesii*, Th.
,, *maculatus*, Th.
,, *fuliginosus*.Giles.
Cellia pulcherrima, Th.
,, *albimana*, Wied.
Neocellia Dudgeonii, Th.
,, *intermedia*, Rothwell.
,, *indica*. Th.
Aldrichia error, Th.
Toxorhynchites immisericors Wlk.
Mucidus scatophagoides. Th.
Desvoidea obturbans. Wlk.
,, ,, var. *fusca*. Th.
,, *panalectros*. Giles.
Stegomyia fasciata, Fabr.
Stegomyia fasciata var. *mosquito*. R. D.
,, *scutellaris*. Wlk
,, *pipersalata*. Giles.
,, *periskelata*. Giles.
,, *tripunctata*. Th.
,, *Thomsoni*. Th.
,, *Assamensis*. Th.
,, *W-alba*. Th.
,, *albolateralis*. Th.
,, (? *microptera*) Giles.
Leicesteria apicalis, Th.
Hulecœteomyia pseudotæniata, Giles.
Phagomyia gubernatoris. Giles.
Neomacleaya indica. Th.
Lepidotomyia magna. Th.
Reedomyia niveoscutata. Th.
Pecomyia maculata. Th.
Pseudotheobaldia niveitarsis, Th.
,, *niveitæniata*. Th.
Theobaldia spathipalpis. Rond.
Theobaldia annulata. Schrank.
Grabhamia ochracea. Th.
Culicada minuta. Th.
Culex mimeticus. Noe.
,, *microannulatus*, Th.
,, *Vishnui*, Th.
,, *impellens*. Wlk.
,, *minimus*. Th.
,, *viridiventer*. Giles.
,, *pulchreventer*. Giles.
,, *nigripes*, Zett.
,, *concolor*, R. D.
,, *fatigans*, Wied.
,, *furcanus*, Wied.
,, *sitiens*. Wied.
,, *angulatus*, Giles.
,, *tipulifarmis*, Th.
,, *albolineatus*, Giles.

Culex biroi, Th.
,, *pallidothorax*, Th.
,, *pallidostriatus*, Th.
,, *trimaculatus*, Th.
,, *christophersi*, Th.
,, *albopicta*, Th.
Leucomyia gelida, Th.
Tæniorhynchus pygmæus, Th.
,, *ager*, Th.
,, *tenax*, Th.
Mansonia uniformis, Th.
Mansonioides annulifera, Th.
Skusea mediofasciata, Th.
Aëdes nigrescens, Th.
Aëdeomyia squamipenna, Arrib.
Anisochelcomyia alboannulata, Th.
Ficalbia minima, Th.
Mimomyia minuta, Th.
Banksiella luteolateralis, Th.
Chrysoconops brevicellulus, Th.
Brevirhynchus magnus, Th.
Radioculex clavipalpus, Th.
Corethra asiatica, Giles.

We may class these genera under four main sub-families as shown below. For further details and generic characters the student is referred to Theobald's Monograph.

A. With long proboscis and scaly wings.
- (*a*) Larvæ without siphon. Palpi long in both sexes .. .. .. *Anophelinæ*.
- (*b*) Larvæ with siphon.
  - 1. Proboscis much curved. Very large species .. .. *Toxorhynchinæ*. (One Indian genus, *Toxorhynchites*.)
  - 2. Proboscis straight or very little curved.
    - Palpi short in both sexes *Aëdinæ*. (includes Indian genera *Aëdes*, *Aëdeomyia*, *Mimomyia*, *Anisochelcomyia*, *Ficalbia*.)
    - Palpi short in the female, long in the male .. .. *Culicinæ*.

B. With short proboscis and hairy wings .. *Corethrinæ*.

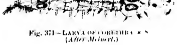

Fig. 371.—LARVA OF CORETHRA × [illegible]
(*After Meinert.*)

DIXIDÆ.

Flies having the general appearance of Mosquitos, but with different venation (Pl. LIX).

As in the case of the *Simuliidæ* and *Orphnephilidæ*. the members of this family are very widely distributed, but all belong to one genus, in this case *Dixa*. They may be regarded as forming a connecting link between the Mosquitos (Culicids) and the Daddy-long-legs (Tipulids). The larvæ live in still or running water. They are of no economic importance. None are as yet recorded from India, but we have found larvæ in a hill-stream at Simla in company with Simuliid larvæ.

BLEPHAROCERIDÆ.

Small gnat-like bare flies, the wings often iridescent with a secondary set of creases in addition to the ordinary venation which is variable. There is no discal cell. The eyes usually separate and divided into two distinct halves, upper and lower.

These curious little flies are found in hilly or mountainous regions, since here alone are found the swift clear streams in which the larvæ and pupæ live. The eggs are unknown. The larvæ are remarkably adapted to life in shallow quick running water, being much flattened and provided with suckers, which enable them to cling like limpets to rocks and stones over which the water flows. The pupæ, of a shape similar to that of the larvæ, are also as a rule entirely submerged, and here we see the reason for the curious creasing of the adult fly's wings. The fly emerges from the pupa under water; anchored to the pupa skin by its long hind legs it reaches up until its body is at the surface, and then after a second or two in this dangerous position it spreads its wings and flies away. In

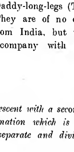

Fig. 372—A BRAZILIAN BLEPHAROCERID LARVA (AFTER MULLER) ENLARGED.

most other flies the wings when first drawn out of the pupa skin are small and flabby, and have to be "pumped up" like a bicycle tyre before they are fit for flight, but with the Blepharocerids the wings, owing to their being folded in the pupa, are ready for instant use when withdrawn, thus saving the fly from being washed away helpless in the stream.

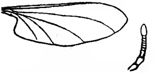

Fig. 373--WING AND ANTENNA OF HAMMATORHINA BELLA. CEYLON. (*After Kellogg.*)

The division of the eyes is a marked feature, and results in a type of eye curiously like that found in some male May-flies. Owing to lack of knowledge of the habits of the flies the use of these peculiar eyes is uncertain. The females are thought to be predaceous, and the males probably suck honey from flowers, but of no species is the full life-history known. The family is fully treated of in Genera Insectorum (Fasc. 56) by Kellogg, and we have copied his figure of the wing and male antenna of *Hammatorhina bella*, the only species hitherto recorded from Asia (Ceylon). Though owing to the larval habits it is unlikely that the flies occur in the plains of India, there is no reason why a careful search in any part of the hills where there are waterfalls should not reveal several new species of these rare and curious little insects: I have already taken one male (genus *Apistomyia*) sucking the flowers of *Composita* at Simla, and a female of a different species in the grass bordering a little mountain torrent.

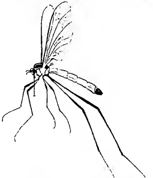

Fig. 374.--A BLEPHAROCERID. SIMLA. × 3.

TIPULIDÆ.

"Daddy long-legs" or Crane-flies. Often large thin flies with long fragile legs. There is nearly always a V-shaped groove on the rounded thorax, and a discal cell present. The costal vein goes all round the wing. Antennæ 6—19, palpi 4-5 joints.

The Crane-flies vary in size from that of a small mosquito to flies having a wing-spread of 3-4 inches. As a rule they may be easily recognised by the V-shaped thoracic suture, and by their legs breaking off when they are caught, the latter peculiarity making it rather difficult to get perfect specimens. As is shown in the figure, the venation is complete, *i.e.*, it has suffered but little of that coälescence and reduction in the number of veins which is met with in some of the more specialized families such as the Cecidomyiids or the Muscids (*e.g.*, the House-fly).

This is one of the reasons why these flies (especially that section of them called *Limnobiinæ*, some of whose larvæ are caterpillar-like in appearance and habits) are often considered to be among the most old-fashioned and conservative of Diptera, departing comparatively little from the primitive type. They are frequently found in amber, together with other flies of which the great majority belong to the division Nemocera. As a rule the Tipulids are dull brown, blackish or yellowish in colour, and one or two European species are wingless.

The sexes are very easily distinguished, the male having the tip of the abdomen bluntly swollen and provided with a complex armament of claspers, while the horny sheath of the female ovipositor is long and tapering.

The eggs are generally cylindrical, sometimes a little tapering at the ends, and dark in colour. The females may sometimes be seen at dusk in damp grassy places flying up and down among the grass in a curiously crazy and aimless fashion. If they are carefully watched, however, it will be seen that every now and then, when the long sharp ovipositor comes in contact with the ground, an egg is deposited; what looked like weakness of intellect turns out to be part of the most important act in the insect's life. The larvæ live as a rule in damp surroundings, in wet earth, under bark, or in putrid water, and some possess long tubes from the tail-end so that they can breathe while feeding under water. The more usual type of tail is blunt, with the openings (spiracles) of the tracheæ surrounded by a ring of stumpy processes. They feed usually on decaying vegetable stuff, and are very often found in the mess which accumulates in hollow trees. The pupæ look not unlike those of Butterflies or Moths. They have the legs straight, and have breathing horns or tubes at the front end, and usually bristles or spines on the abdomen, which enable the pupa to work its way free when the insect is about to emerge. They are found in or near the place where the larvæ lived, in mud, sand, earth, or decaying leaf-mould.

In Europe the larvæ of Tipulids often cause great damage to grass lands, living just under the surface and eating the roots of the grass. Enough is not yet known of the Indian forms, however, to say whether or not they are of economic importance in this or any other respect, though it is unlikely that in the dry conditions of the plains they occur in sufficient numbers to do much damage, except possibly on large grass lawns kept well watered throughout the year. They are not very common in the dry plains, but abound in the moister country of the hills. Pl. LX, fig. 1, represents a strikingly-coloured species apparently widely spread over India.

More than a thousand species are known, but only twenty-six have till lately been recorded from India, nearly all of them from the hills, Van der Wulp lists 16, and the remaining 10 were described by De Meijere. Brunetti has, however, recently described a number of additional species (Indian Museum Records). No habits or life-histories seem to have been studied at all. The three main divisions of the family are as follows :—

A. Distinct **V**-shaped suture on the thorax.

1. Last joint of palpi shorter or very little longer than combined length of preceding joints. Antennæ 6—16 joints. .... *Limnobiinæ*.

2. Last joint much longer than this. Antennæ not more than 13 joints. .... *Tipulinæ*.

B. No distinct V-mark on the thorax. .... *Ptychopterinæ*.

CECIDOMYIIDÆ.

Minute delicate flies. Antennæ long, generally with whorls of hair on the joints, especially in the male. Legs long and slender; tibiæ without spurs; coxæ not elongated. Wings broad, rather hairy, with veins few and weak; the media usually absent.

These minute flies, though very inconspicuous in the adult condition, sometimes make their presence severely felt while in their immature stages from the damage they inflict on various crops in America and Europe. The most widely known of these pests is probably the "Hessian fly," a destructive enemy of wheat in Europe, America, and New Zealand.

The larva of this fly (*Cecidomyia destructor*, Say) lives between the leaf and the stem of the wheat plant which becomes so enfeebled by the attack that it bends over, and gives practically no seed. When full grown the animal before becoming a pupa exudes a substance which stiffens into an outer covering, giving it rather the appearance of a flaxseed, this resting stage being hence often called the "flax-seed stage." As a general rule preventive measures are difficult, as they depend on destroying as far as possible, by hand-picking the affected plants containing pupæ, the first brood of the flies, which necessitates early recognition of the attack. Under natural conditions the flies appear to be kept in check by hymenopterous parasites, and probably do serious damage only when these parasites are from some cause rendered inefficient.

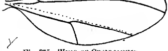
Fig. 375—WING OF CECIDOMYIID. (*After Comstock.*)

Besides those forms whose larvæ live in the above manner there are very many others which lay their eggs in various other parts of plants. The presence of the egg or larva, or the injection of some irritating fluid, results in a kind of local inflammation which produces a gall on the plant and in this gall the larva developes. To facilitate the laying of the eggs in the proper place the ovipositor in some species is very much elongated.

The larvæ of Cecidomyiids are somewhat curious; they are small-headed maggots often red or pink, tapering slightly at both ends, with one segment more than is usual in dipterous larvæ (*i.e.*, 14 instead of 13 including the head) and have a little horny hook (the "anchor-process") on the under side of the front part of the body, possibly used for changing the position of the larva or for breaking up the substance of the gall to prepare it for eating. In addition to this, some of these larvæ (*Miastor*) have the extraordinary power of producing young ones in their interior, and that not by means of the development of testes and ovaries and subsequent fertilisation, but by simple growth, a kind of "vegetative reproduction." These young larvæ eat their way out of the parent-larva's body, and either pupate in the ordinary way or themselves produce another generation after the same fashion.

The pupæ of Cecidomyiids may be either free or enclosed in cocoons. As regards the exact method whereby these cocoons are constructed there is much uncertainty; some are spun in the usual way, but others appear to come into being without exertion on the part of the larva, which seems to remain quiescent while the cocoon grows round it. It is supposed that some process of sublimation takes place (*cf.* p. 580).

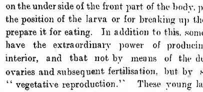

Fig. 376—The lower figure shows a hymenopterous parasitic grub at the beginning of its attack on a Cecidomyiid pupa. The upper figure shows the great growth of the grub after two days, the pupa being almost entirely consumed.

The pupæ look very much like those of minute Lepidoptera, with the legs straight and free from the body at the ends. We figure a species found in galls on a wild plant at Pusa (fig. 2, Pl. LX), and the same pupa attacked by the larva of one of the hymenopterous parasites to whose attacks the members of this family seem particularly liable (fig. 376).

In Europe and America these flies have been a good deal studied, and something like a thousand species described, but in India two species only have been recorded: one of them which attacks rice after the manner of the Hessian fly, was described by Wood-Mason under the name of *Cecidomyia oryzæ*, from Bengal, but since his time nothing seems to be known of it except for one severe outbreak in South India when the pest was completely destroyed by parasites.

Another species, *Oligotrophus saligneus* (fig. 377), has been found on Willow, and one has been bred at Pusa from the spores of wheat-rust.

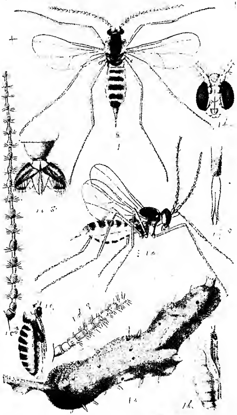

Fig. 377—OLIGOTROPHUS SALIGNEUS. BELOW IS THE GALL WITH PUPA-SKINS PROTRUDING. 1c. REPRESENTS THE MALE ANTENNA, 1e. THE MALE CLASPING ORGANS, 1f. THE OVIPOSITOR. [I. M. N.]

There certainly exist a very great number of Indian species as yet undescribed. The flies are common in the plains and extremely abundant in the hills.

The family is separated into two groups, the *Lestremiinæ*, with a media, and the *Cecidomyiinæ*, without a media.

MYCETOPHILIDÆ.

Fungus-gnats. Mostly small flies with elongated coxæ. Antennæ long, generally without whorls of hair. Two or three ocelli present. Eyes separate in both sexes. All the tibiæ with spurs. Male genitalia easily seen.

These delicate and slender flies can generally be easily recognised by the above characters. They might perhaps be occasionally confounded with Bibionids (as their colour is sometimes black and orange) or with Tipulids or Cecidomyiids, but the long antennæ and coxæ, with the venation, are sufficiently characteristic.

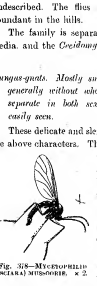
Fig. 378—MYCETOPHILID (SCIARA) MUSSOORIE. × 2.

As to the venation, the costa extends as far as the last branch of the radius (which may be 3 or 2 branched), the sub-costa may be very small or well developed, the media and cubitus are 2 branched, while the anal varies in length. There is considerable variation in the arrangement of the veins in the neighbourhood of the radio-medial cross-vein, and this variation supplies useful characters for purposes of classification.

These flies require for their development damp surroundings, and hence are much more abundant in the hills than in the plains. They sometimes indulge in dances, generally about low shrubs or near their breeding-places. The prominent genital forceps of the males (fig. 378) renders the distinction of sexes easy, for the female has the abdomen pointed, with two very small terminal processes.

The eggs are often extruded in little chains of a dozen or so at a time. They are laid in fungi, dead damp wood, dung, decaying leaves and similar substances. The larvæ have a shiny look, and are generally rather transparent, so that the longitudinal tracheal tubes show plainly through the skin. They are smooth and round, with as a rule a few small [illegible] on the under side. There are 9 pairs of spiracles, on segments 1 and 4-11 with none on the last segment. The head is quite distinctly separate from the body, and is horny, with a pair of strong flat jaws. Many of the larvæ secrete a slimy silky substance with which they spin a kind of web over their food and subsequently a cocoon within which they pupate. Their habits are often very curious and interesting; for instance, the gregariousness of the larvæ of some of the Sciarinæ, which travel about stuck together with slime in large snake-like masses sometimes three or four yards long; the extraordinary form of *Mycetophila ancyliformans* which looks exactly like a small Mollusc, the shell being represented by a spirally-marked case of excrement which is carried on the back (fig. 379), and the strong luminosity recorded as being exhibited by a New Zealand *Bolitophila* (*B. luminosa*). The pupæ are as a rule smooth, without points, spines, or bristles, and not enclosed in the larval skin; they are generally protected by a cocoon, which is, however, often very slight and delicate. On emergence the abdomen of the fly, more especially of the female, is often noticeably long and large, and takes some time to shrink to its normal size, this telescopic extension of the posterior abdominal segments being also very obvious during oviposition. The whole life-history occupies as a rule about three weeks or a month in temperate climates.

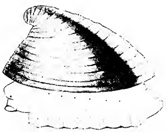

Fig. 379—LARVA OF MYCETOPHILA ANCYLIFORMANS (AFTER HOLMGREN) MUCH ENLARGED.

The larvæ are essentially scavengers, apart from this being of little importance economically, and though in Europe they sometimes attack stored potatoes and apples, this is probably only in cases where the apples or potatoes are already bruised or slightly decayed. Mushroom-growers have sometimes suffered heavy loss from their attacks.

About a thousand species of *Mycetophilidæ* are known, distributed all over the world. From India Van der Wulp records only four species, belonging to the genera *Sciara*, *Mycetophila* and *Platyura*, but there are in reality a very large number, more especially in the hills, where the flies are extraordinarily abundant, the conditions found there being exactly suitable for the larvæ. *A Sciara* has been reared at Pusa from mushrooms, and members of this sub-family (*Sciarinæ*) are extremely common at Mussoorie and Simla, (fig. 378) where we have also found representatives of the sub-family *Macrocerinæ* rather common at light, these latter being conspicuous by reason of their unusually long antennæ.

The family has been monographed by Winnertz (Verhand. Zool. Bot. Ges. 1863) and most of what is known of the larvæ will be found in a paper by Osten Sacken (1886), reprinted from Proc. Ent. Soc., Philadelphia, 1862, on "The characters of the larvæ of Mycetophilidæ."

The determination of species is often rather difficult, as the specific characters are frequently minute and require very careful discrimination. The genera and sub-families are mostly distinguished by differences in the venation, which shows considerable variation in the family. The following table of sub-families is modified from Williston. (The *Sciarinæ* are now sometimes separated as a distinct family and called *Sciaridæ*).

1. Coxæ moderately long Cross-vein looking like .. *Sciarinæ.*
part of R_2; cubitus forked near base of wing.
Coxæ very; long Cross-vein not in same line as R_2 2
2. Media arising near base of wing. Anal more or less
incomplete. 3
Media arising near middle of wing. Anal complete 4
3. R_1 branched, the branch generally looking like
an extra Cross-vein between R. R_1 and R_s : 3
ocelli present .. .. .. *Sciophilinæ.*
R_1, not branched, 2 or 3 ocelli .. .. *Mycetophilinæ*
4. R_s reaching the costa, and arising from R_1 at or
near the Cross vein .. .. . *Mycetobiinæ.*
R_s generally short and transverse, ending in R_1 5

5. Media not coälescing at any point with R_2 or R_4.
Cross vein present .. .. .. *Bolitophilinæ.*
Media coälescing for some distance with R_3 or R_4.
Cross-vein absent.
Antennæ very long .. .. .. *Macrocerinæ.*
Antennæ short and flat .. .. .. *Ceroplatinæ.*

BIBIONIDÆ.

Medium sized ugly-looking flies. Antennæ with 9-12 rather thick joints closely pressed together. Ocelli present. Front femora rather thick, front tibiæ generally spined. Eyes of male close together or touching. Anterior veins thicker than the others. Wings often dark or with dark spots.

These flies are easily recognised by their sluggish movements (though they have large wings), and by their colour being almost always either black or orange-red. In many species the male is black while the female is partly orange, as is also the case with some Mycetophilids (*Sciarinæ*). Their lazy habits and conspicuous colour-scheme suggest that the orange and black might represent in this case, as apparently in others, the "warning colours" of the distasteful and dangerous members of insect society, but no observations confirming this supposition appear to exist.

The wings have conspicuous alulæ. The sub-costa is generally rudimentary and the radius is often only two-branched. The flies might perhaps be confused with *Mycetophilidæ*, since some of the latter are also black and orange, possess ocelli, and have often dark-coloured wings whose venation is not unlike that of a Bibionid. The two can be easily distinguished by looking at the antennæ and the coxæ of the legs, both of which are much longer in Mycetophilids than in Bibionids.

The eyes in *Bibio* are divided (in the male flies) into two distinct upper and lower halves, separated by a narrow band. More or less well marked differences in the structure of different parts of the eye, usually in the size of the facets, occur in other flies. (Cf. Blepharocerids, Simuliids, Tabanids, Dolichopodids, Pipunculids.) Since, owing to the internal arrangements of facetted eyes, clearness of vision increases with the number of facets in the parts of the eye employed, we may suppose the sparsely-facetted areas to be used merely for the perception of comparatively gross differences of light and shadow and of the motion of large objects, while the closely facetted parts are of use in cases where more accurate discrimination is wanted for nearer objects. The larvæ are grub-like, and have a horny head and jaws. They feed mostly on decaying matter, being often found in numbers in the farmyard manure applied to fields, but they also sometimes affect a diet of fresh vegetables and occasionally do damage in Europe by eating the roots of grasses. The pupæ are generally free but some remain inside the old larval skin, through which project two branched tubes for breathing. The family numbers about three hundred species from all parts of the world. The known Indian species belong to three genera, namely *Bibio*, *Plecia*, and *Dilophus*. We have reared also of a species *Aspistes* from rotting roots of ginger. These genera are distinguished as follows :

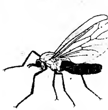

Fig. 380—FEMALE BIBIONID (PLECIA) × 2.

2nd basal cell absent, antennæ with 12 joints	... *Aspistes*.
2nd basal cell present,	
Radius 2-branched, front tibiæ spineless	... *Plecia*
Radius 2-branched, front tibiæ with a spine-like process at the tip	... *Bibio*
Radius 2-branched, front tibiæ with a circlet of spines.	*Dilophus*.

SIMULIIDÆ.

Small fat flies. Antennæ rather short and tapering, with 10 joints close together. Eyes touching in the male. No ocelli. Thorax humped. Wings broad, with only the anterior veins well-developed. Legs rather stout, tibiæ not spurred.

There is only one genus (*Simulium*) in this family, but this contains from fifty to a hundred known species which are widely distributed. In India they are most generally known as "Potu" or "Pipsa." In Europe and America they sometimes occur in vast numbers and do great damage to live-stock. The females suck blood, and their attacks not infrequently result in the death of the victim, whose eyes, nose, and ears are the points to which the pest mainly directs its attention. The bite leaves a small purple spot like a blood-blister, and may cause considerable irritation. In America one species (*S. pecuarum*) has caused much

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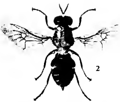
loss among mules, horses, cattle, sheep, hens, turkeys, pigs, dogs, and cats. Smoke or Kerosene are preventives. The larvæ of all the known species appear to live in quickly running water, which explains the general absence of Simuliids from the plains. Larvæ have, however, been observed in quite a slow stream near Igatpuri, while two adult flies have been taken during the hot weather at Pusa, though no larvæ have been discovered in the rather sluggish river which is the only running water there. The nearest rapid stream is probably at least fifty miles away. The larvæ are curiously adapted for their mode of life, having a sucker at the end of the body, wherewith to cling to stones, a foot-like process on the 1st thoracic segment, and large brush-like mouthparts, whose motion sweeps into the mouth the microscopic water-plants on which the creature feeds. The larva can spin threads which help to protect it from being carried away by the rushing water, and when full grown it spins a pocket-shaped cocoon which is stuck to stones and in which it pupates; the pupa has two much-branched breathing filaments which project from the open front of the cocoon. (Pl. LXI.) The fly emerges under water and floats to the surface, protected from getting wet by a bubble of air or gas entangled among the hairs on the legs and body. In the figure of the wing (Pl. LXI, fig.1) it will be seen that the strengthening of the anterior veins at the expense of the posterior ones has been carried much further than in the Bibionids, the only well marked veins being the costa, subcosta, the 2-branched radius, and the basal part of the media connected with the radius by the anterior cross vein. Some other small flies, *e.g.*, *Phoridæ*, have a venation at first sight somewhat similar to this, but their antennæ are quite different to those of *Simulium*. (Pl. LIX.)

The eyes in this family contain both large and small facets (see *Bibionidæ*), and afford an easy means of distinguishing the sexes, since the male eyes touch while those of the female are separated. The flies are usually coloured with some combination of grey, black, and golden yellow. The Indian species have not been properly studied, only *Simulium indicum*, Bech (Ind. Mus. Notes), and *S. indianum*, Big., having been described, and when the species of the hill districts have been collected there is little doubt that they will be found to include a considerable number.

PLATE LXI.—SIMULIIDÆ AND STRATIOMYIIDÆ.

Fig. 1. *Simulium* sp. (Simuliidæ). × 8.
,, 1*a*
,, 1*b*. } Larva and pupa, the latter lying in its open cocoon. × 8.
,, 2. *Clitellaria heminopla*, Wd. (Stratiomyiidæ) × 3.
,, 2*a*. Larva. × 3.
,, 3. *Sargus metallinus* ,, × 3.
,, 4 *Plecticus aurifer* ,, × 3.
,, 5. *Pachygaster* sp. ,, × 3.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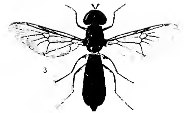
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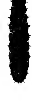
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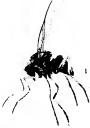
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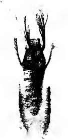
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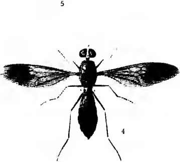
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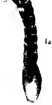

1a

The one whose stages are figured on Pl. LXI is common in the neighbourhood of Simla at the end of the rains. No really practical method of exterminating the flies is known, though the use of heavy oil in the streams has apparently been tried with some success in America.

ORPHNEPHILIDÆ.

Small bare flies with eyes contiguous in both sexes (not as is usual in the male only), and an unusual type of venation. Antennæ not longer than the head.

These small flies are rare, but widely distributed. Nothing is known of their habits and life-history. They are of no economic importance, though of interest to the systematist from the difficulty of determining their relationships. None are known to occur in India.

RHYPHIDÆ.

Discal cell present. Empodia pulvilliform, pulvilli rudimentary or absent. No transverse suture on thorax.

These flies look rather like small Tipulids with broad wings, the latter generally spotted. They are widely distributed, but the species are few. They are fond of shady places and are sometimes found on windows. The larvæ are mostly aquatic, wormlike, amphipneustic, with two fleshy projections on the hind end. They are also found in rotten fruit, manure and decayed wood. The pupæ are free. Two species are recorded from India. *Rhyphus fenestralis*, Scop., which occurs in the hills, and *R. pulchricornis*, Bru., from Assam. I have not yet been seen them in the dry plains. The venation is shown on Pl. LIX.

ORTHORHAPHA BRACHYCERA.

STRATIOMYIDÆ.

Medium-sized flies, not bristly. Head usually as broad as thorax, abdomen often flattened. Ocelli present. Eyes frequently touching in the male, often with coloured bands as in Tabanidæ. Antennæ variable, 3-jointed, the 3rd joint a complex of small segments and often with a terminal style or arista. Scutellum often spined or with serrated edge. Anterior veins often crowded and thickened, the others weak. Four or five posterior cells present. Costa rarely reaches to tip of wing.

This is a large family of often very beautiful insects, but unimportant from the economic point of view. In their adult condition they are found about flowers and leaves, and the larvæ are many of them scavengers. The flies are generally lazy and not easily frightened, and are fond of sitting on leaves near the ground in damp rather shady places. Pl. LXI, fig. 3, shows the commonest species of the plains (*Sargus metallinus*) and give some idea of the beautiful colouring which these flies often show. The wings are carried at rest lying flat over each other along the abdomen and the members of the family have generally a characteristic look about them which makes them easy to recognise; where there is a doubt, a glance at the antennæ and venation will in most cases be enough to resolve it.

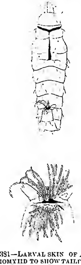


Fig. 381—Larval skin of a Stratiomyiid to show tail-fringe. Upper fig. × 2.

The sexes may be distinguished by the distance apart of the eyes. The larvæ, which are sometimes predaceous, are found in various decaying substances, under bark or in the sap exuding from it, and often in water, even occasionally in salt water and hot springs. The aquatic forms often possess a beautiful hair-fringed tail-cup (fig. 379) which floats and keeps the posterior spiracles at the surface. The skin of the larva is often very strong and hard, frequently covered with a sort of chalky layer which helps to stiffen it, and when the larva pupates this larva-skin separates from the pupa but remains enclosing it as a protecting outer case. Interesting accounts of the structure and habits of these larvæ will be found in Miall ("Aquatic Insects").

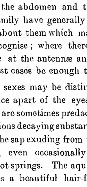


Fig. 382—Larva of a Stratiomyiid, ventral view.

The student will find a list of genera and species in Indian Museum Records (Brunetti).

The *Clitellarinæ* (Pl. LXI. fig. 1) and *Sarginæ* are common in India, but the curious little dumpy round-bellied *Pachygastrinæ* (Pl. LXI, fig. 5.) whose flattened predaceous larvæ live under bark. are less often met with. The venation typical of these three sub-families is shown in fig. 381.

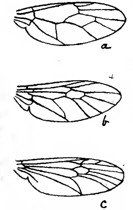


Fig. 383—STRATIOMYIID VENATION (AFTER COMSTOCK). *A* PACHYGASTER, *B* CLITELLARIA, *C* SARGUS.

LEPTIDÆ.

Antennæ variable as in Stratiomyidæ. Eyes often touching in the male. Proboscis sometimes long and beak-like. Pulvilli and empodia present. At least some of the tibiæ with spurs.

Leptids are of moderate size, being rarely quite small, with the legs and abdomen both rather long and thin, the latter somewhat tapering at the hind end. The head is wide and the eyes large. The body is frequently covered with a close coat of short hairs sometimes golden yellow in colour. and when at rest the wings are not folded over the back as in Stratiomyids but are held apart after the manner of the *Tabanidæ*. The usual type of venation is shown on Pl. LIX. The flies are of rather sluggish habit, with a short silent flight, and are predaceous: two genera, *Symphoromyia* and *Trichopalpus*, are said to suck blood freely in America, while cases are also on record of people in Europe having been bitten by *Leptis* ; no Indian species is yet known to suck blood : the family, as a whole, certainly does not occur in any abundance in the plains. None have ever been seen at Pusa, though the flies are apparently not uncommon in Assam and in the Eastern Himalayas. The sexes are distinguished by the wider separation of the eyes in the female. The breeding-habits

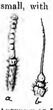


Fig. 384—ANTENNÆ OF LEPTIDS. (*After Comstock.*)

appear to be not unlike those of *Tabanidæ*, the eggs being laid on plants overhanging water or in damp woody places. The predaceous larvæ are aquatic or live in decaying wood or moist earth and moss. One species is known to make a pit like an ant-lion and catch food in the same way. The larvæ of *Xylophaginæ* sometimes have the head and anterior part horny and drawn out to a point at the end of which is the mouth. The family comprises two or three hundred widely distributed species, and is divided as follows, the *Leptinæ* containing most species. The *Xylophaginæ* often have a considerable resemblance to Hymenoptera.

(*a*) Antennæ not long, 3rd joint apparently unsegmented, with a style or arista .. *Leptinæ*.
(*b*) Antennæ longer, 3rd joint complex.
  (1) All the tibiæ spurred .. .. *Xylophaginæ*.
  (2) Front tibiæ without spurs.. .. *Arthroceratinæ*.

TABANIDÆ.

Dans-flies, Gad-flies, " clegs." Body usually rather broad and flat. Head large, broad and flat, the eyes large, touching in the male; often with coloured spots or stripes. Antennæ projecting, 3rd joint made up of several segments. Proboscis strong, pointing downwards, sometimes (Pangonia) very long and horizontal. No bristles on the body. Squamæ well developed. Wings fairly large, the costa extending all round, when at rest held separated (except Hæmatopota) not folded flat over one another.

Dans-flies are easily squashable, generally fairly large flies, at least as big as a bluebottle, and often bigger. They are well known from the blood-sucking habits of the females, and are in some districts a constant source of annoyance to horses, cattle, men, and other animals. Their bite is severe, but generally does not result in so much swelling and subsequent irritation as does that of the mosquito; sometimes, however, this is by no means the case, and very considerable discomfort may be experienced. It is probable that

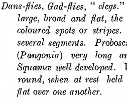


Fig. 385—MOUTHPARTS OF FEMALE. *Tabanus*. (*After Hine.*)

mxp	PALPUS
mx	MAXILLA
mn	MANDIBLE
hpx	HYPOPHARYNX
lbr	LABRUM

PLATE LXII.—TABANIDÆ.

Fig. 1. *Tabanus* sp Wlk x 2.
,, 1*a*. Egg mass x 2.
,, 1*b*. Young larva x 8.
,, 1*c*. Full-grown larva. x 1.
,, 1*d*. Pupa. x 2.
,, 1*e*. Parasite. x 8
,, 2. *Tabanus* sp. x 2.
,, 3. *Pangonia longirostris* x 2.
,, 4. *Gastroxides ater* x 2
,, 5. *Hæmatopota* sp. x 2.
,, 6. *Chrysops dispar* x 2

1a

1b

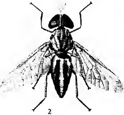
1c

1

1d

1e

3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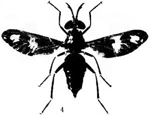
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such results are due, not to any poison secreted by the insect, but to dirt accidentally introduced into the wound either by the fly's proboscis or in some other way.

Unlike most mosquitos, *Tabanidæ* bite only during the day time, but they resemble the former in that the females alone are blood-suckers. The males live on nectar or the juices of plants and fruits, and the females can also subsist on vegetarian diet if they are unable to get blood. Both sexes have been observed feeding on the sugary substance exuded by Aphids, and it seems probable that some species of *Pangonia* (females) do not include blood in their diet: we have observed them sucking composite flowers at Simla, but never biting. One species of *Tabanus* at Pusa appears to drink water when on the wing, like a swallow, and those that we have kept in captivity have drunk freely of sugar and water, and of "*Hæmatogen*" (a blood-like patent medicine). The sexes are generally easily distinguished by the eyes, which touch one another in the males and are separate in the females.

The majority of blood-sucking flies have aquatic or semi-aquatic larvæ, and the Tabanids, as a family, form no exception to this general rule. The eggs (fig. 1*a*, Pl. LXII) which are usually dark-coloured and cigar-shaped, or sometimes curved and with a white incrustation, are generally laid arranged in more or less regular masses on leaves or stems of plants overhanging water or the mud at the edge of water. When the eggs hatch the larvæ fall out into the water, whence they soon make their way to the mud at the bank, where they live until full grown, eating living or dead insects, and in captivity preying on one another when food is scarce. When full grown they leave the water's edge and make their way further up the bank where they pupate just below the surface of the ground. The larvæ are apparently metapneustic, with well developed mouth-hooks, a retractile head, and the body-segments usually furnished with prominent tubercles bearing small claw-like spines which assist in locomotion. The tail is usually more or less prolonged into a retractile breathing-tube, and a round double swelling below marks the anus. A characteristic feature

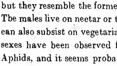

Fig. 386—MOUTHPARTS OF FEMALE *Tabanus*, SHOWING ABSENCE OF MANDIBLES. (*After Hine.*)

is the longitudinal striation of the whole body, but this is sometimes only very faintly marked. One Pusa species *Gastroxides ater* (Pl. LXII, fig. 4) lives in hollow trees.

Some of the larvæ have the power of emitting a sound, a tiny squeak or click, like the noise made by a small electric spark. It has been supposed (Paoli, Redia, 1907) that a curious structure known as "Graber's organ" (fig. 387) is concerned either with the perception of such sounds; this organ can be seen in the living larva as two or three pairs of small black dots under the skin, the number and arrangement varying to some extent in different species. The form of the tail, breathing tube, and tracheæ are also helpful in distinguishing the larvæ, as are also the shape and number of the tubercles and the arrangement of the small bristles on the body-segments.

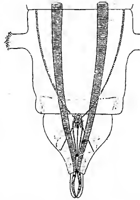

FIG. 387—TAIL END OF TABANUS LARVA, SHOWING GRABER'S ORGAN LYING BETWEEN THE BIG TRACHEAL TUBES. (*After Paoli.*) MAGNIFIED ABOUT EIGHT TIMES.

The pupa is found in the earth: it lies free of the larval skin, and has usually rings of bristles on the abdomen and some spines and tubercles on the head and thorax (fig. 388). The thoracic spiracle is rather large and roughly crescent-shaped. At Pusa there are apparently three broods of *Tabanus* yearly, flies emerging at the beginning and end of the hot weather (about February and June) and at the end of the rains (October). Hibernation takes place in the larval condition through the cold weather in all those species with which I am acquainted at Pusa.

Some species are attacked by small Hymenopterous egg-parasites, (Pl. LXII, fig. 1*e*.), which in the case of one species of *Tabanus* we have found in a considerable proportion of the eggs observed, though the flies were common in spite of this. No practical method of getting rid of the flies has ever yet been found, except clearing their breeding-places. Their destruction is desirable since they are practically certainly concerned in the spread of diseases of horses and cattle. They can to a certain extent be kept from biting by the application of kerosene- or crude-oil emulsion, the effect sometimes seeming to last for several days after application. The family contains between one and two thousand species, which occur all over the world. Though the genera are very widely distributed, the range of many individual species seems to be comparatively restricted. The differences between the species are often extremely slight, and the family as a whole shows a coherent assemblage of forms closely following one or two common patterns. It is thus very easy to recognise a fly as a Tabanid, and often difficult to find out what Tabanid it is. The table indicates the distinctions between the genera more commonly found in India. The number of species known is doubtful (V. D. Wulp lists over fifty) and they are at present undergoing revision. All these genera are figured on Pl. LXII.

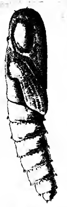
Fig. 388—PUPA OF TABANUS × 4.

Antennæ much longer than the head	*Chrysops.*
Antennæ not as above.—	
(1) Proboscis very long	*Pangonia.*
(2) Proboscis short. Resting position with wings flat, separated	*Tabanus.*
(3) Resting position with wings nearly parallel with the sides of the body. Wings usually brown, spotted with white . ..	*Hæmatopota.*

CYRTIDÆ.—(*Acrocerida*).

Medium-sized or small flies. Head often very small, eyes usually meeting in both sexes. Antenna variable, 3-jointed with a terminal style, which may be absent. Venation variable, veins often faint. Thorax large and round, squama very large, abdomen very large and round. Mouth-parts variable, often rudimentary.

These very curious flies are easily recognized by their small downbent head, humped thorax, and very large squamæ and abdomen, the latter often of extraordinary rotundity. Probably the only other flies with which they might be confused are Stratiomyids belonging to the division *Pachygastrinæ* (Pl. LXI, fig. 5), and from these the squamæ and venation will distinguish them. They are never bristly, sometimes hairy, generally quite smooth. The life-histories are not well known, but the larvæ seem to be parasitic in the egg-cocoons or the bodies of spiders. The fly's eggs are said to be laid, not on the spider or among its eggs, but on grass and stems whence in some unknown fashion the larvæ get in touch with their unwilling hosts.

The family is quite a small one and its members are as a rule uncommon. *Oncodes costalis*, Wlk., is recorded from India; we have taken another undetermined species at Mussoorie (Pl. LXIII, fig. 11), flying about Convolvulus flowers, and at Pusa in grass and low herbage.

NEMESTRINIDÆ.

Moderate-sized hairy flies with characteristic venation. Antennæ short, 3rd joint simple with a thin terminal jointed style.

The peculiar venation (fig. 387) characterises this small though widely-spread family. About a hundred species are known, and their habits are similar to those of the *Bombyliidæ*, *i.e.*, they are flower-flies, and suck nectar.

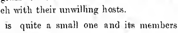

Fig. 389—NEMESTRINID WING.
(*After Williston.*)

The life-history of one species is partly known and is very curious. The eggs are laid in the burrows of a boring beetle (*Anthaxia*) whence the larvæ issue in numbers and are wafted away by the wind. After this it would seem probable that they cling to beetles (in this case a Cockchafer), and are carried with them into the ground when they lay their eggs, subsequently feeding on the beetle-larvæ which hatch. Exactly how they get to the beetle-larvæ is not, however, known with any certainty (Williston).

The flies are rare, and seem to be usually caught on hill tops, or flying about the tops of big trees. The Indian Museum collection contains one species (*Hirmoneura montana*, Bru.) from Mussoorie, and there is an unnamed *Trichophthalma* from India in the British Museum.

BOMBYLIIDÆ.

Antennæ 3 jointed, the terminal style small or absent. Head generally rounded, eyes often meeting above in the male. Proboscis long and thin or short and thick. Body generally downy, or with thick fur, sometimes with scales. Legs usually thin and rather long, feet small. Radius four-branched. Basal cells long. Squamæ small. Wings often with a dark pattern.

This large family (some 1,500 species are known) is one which forms a characteristic feature of the fly fauna of the plains. Its members are found in all dry districts, and can be seen hovering about sun-burnt banks and paths and in the most arid and unpromising situations. Their flight is extremely rapid and well regulated: I once timed a small *Anthrax* hovering about a twig, and for nearly six minutes it remained within a space of certainly not more than a cubic inch in extent. When disturbed they dart away like lightning, a habit which renders their capture rather difficult to accomplish without extravagance in time and nervous energy: a great saving in these respects is gained by stealthily bringing the net as near as possible and then enclosing the fly with a rapid jerk: about sun-set they can often be found by sweeping grass. The two main types to which the majority of the genera belong are the *Bombyliinæ*, hump-backed furry forms with long thin proboscis, often looking a good deal like bees, and the *Anthracinæ*, which are not hump-backed, have a relatively larger head, longer abdomen, and short proboscis. Though many Anthracines are clothed with thickish hair they are not so characteristically furry as the *Bombyliinæ*, and some are almost bare, these latter having some slight superficial resemblance to small *Tabanidæ*. The majority of the commoner species of the plains belong to the Anthracine type, though *Bombylius* and allied genera are not uncommon, especially after the rains. The sexes differ in the distance between the eyes, those of the males being closer.

The chief importance of these flies lies in the mode of life of the larvæ, which are found as parasites in or on the eggs or larvæ of other insects. The hosts are mostly Hymenoptera, but other groups, including *Acridiidæ* (Locusts), are known to be attacked, and a species of *Geron* (*G. argentifrons*, Bru.) has been found at Pusa parasitic on a Tortricid moth, *Laspeyresia jaculatrix*. It is not uncommon to see female Anthracines hovering up and down over the surface of brick walls and other places where nests of Hymenoptera are likely to be, evidently exploring to find a suitable place for their eggs: these they seem to jerk from the abdomen while still on the wing, as described by Fabre, but no Indian species have yet had their life-histories properly traced. They carefully inspect likely-looking holes and cracks in bricks or wood, and we have more than once beguiled the common *Argyramœba distigma* into wasting much time over an attractive "hole" painted on a piece of paper pinned up on the wall or the verandah of the bungalow. From the biological point of view the chief interest of these life-histories centres in the very remarkable changes of form undergone by the larvæ, each change being specially adapted to help it in the progressive stages of its career. Fabre has studied these changes in the case of an *Argyramœba* and the following account of his work is abridged from Dr. Sharp's volume on Insects (Pt. II) in the Cambridge Natural History. The victim in this case is the Mason-bee (*Chalicodoma*), one of those Hymenoptera which build hard nests of mud, like those commonly seen about the corners of bungalow walls and such like places. The parent fly hovers over one of these nests and drops upon it a minute egg whence emerges a tiny slender larva hardly $\frac{1}{20}$ inch long. After remaining quiet (all the time in a fasting condition) for about a fortnight, the little animal begins with extraordinary energy and perseverance to explore the surface of the nest until it finds some tiny crack large enough to give it access to

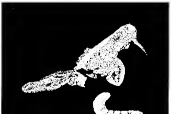

Fig. 390—LARVA OF HYPERALONIA IN RESTING STAGE, LYING NEAR THE DESTROYED SCELIPHRON LARVA SHOWN ABOVE IT × 2.

the interior. Once there, the slender lissom shape is useless, and it now changes to a thickish grub with a delicate sucker-mouth, which it applies to the body of the luckless bee-larva, whose juices are thereby gradually absorbed without any perceptible wound being inflicted; when this treatment has lasted about a fortnight nothing remains but an empty skin. The fly-larva, now fully grown, remains quiescent for some months (cf. fig. 390) and then changes to a pupa, which like the other stages shows a remarkable fitness for meeting the requirements of its position.

Of these the most pressing is obviously the necessity of ultimately being able to escape from its stout clay prison-cell, and for this end the pupa is furnished with six hard and strong spines on the head used for demolishing the surrounding masonry, and some horns and thick bristles on the tail and body. The pupa is thus enabled to break its way to the open air, and the fly then emerges, leaving the pupa skin still fixed in the wall of the bee's cell.

These successive adaptations to changing conditions recall other cases of "hypermetamorphosis," such for instance as that undergone by some of the Blister beetles (*Cantharidæ*), and it is interesting to notice that the mode of life is very similar in these two insects, the beetle-larvæ being parasitic on locusts and Hymenoptera, just like the fly-larva whose career we have sketched above: both of them, as minute and active individuals, start life fasting, so that in the end they may win through to

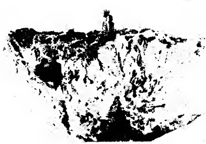

Fig. 391—Pupa-skins of Hyperalonia in nest of Sceliphron × 2.

the all-important egg or grub on which their life depends. While they have nothing to do but eat, both alike suffer a degradation of form and a loss of activity, which latter is in each case partially regained in order to permit of the final changes to the perfect insect. Such life-histories as these offer a fascinating subject for study, and for this India, owing to the abundance of the flies, should afford excellent opportunities. Fig. 391 shows the clay cell of one of the common Hymenoptera of India (*Sceliphron madraspatanum*) which has been penetrated by Anthracine larvæ (*Hyperalonia sphynx*). The pupa-cases of the fly, still sticking in the clay wall, show the big spines which enable the pupa to burst out of its cell when the insect is ready to emerge. A remarkable genus found in the hills, very unlike most of the other Bombyliids, is *Systropus*, figured on Pl. LXIII, fig. 4; their resemblance to thin-bodied Hymenoptera, especially when they are flying, is extremely close. Another very curious genus, *Empidideicus*, is represented by a minute fly occasionally found in grass at Pusa, in which the proboscis is so long and thick as to have the appearance of an elephant's trunk. A list of Indian genera and species is given by Brunetti (Indian Museum Records).

APIOCERIDÆ.

Two or three genera of rare flies, whose systematic position is doubtful. They may be *Asilidæ* or *Mydaidæ*. They are not known from India.

SCENOPINIDÆ.

Rather small bare black flies. 3rd joint of antennæ simple and elongate. Noarista. Ocelli present. Eyes usually touching in the male. Abdomen of seven segments, rather flat. 1st posterior cell narrowed or closed.

These flies are rather uncommon in the plains, and form a very small family, all of one genus *Scenopinus* of no particular interest. One species (Pl. LXIII, fig. 10) is not rare in the hills, and looks rather like a small black Stratiomyid, but from 'his family the venation and the absence of spines or serrations on the scutellum give enough distinction. The larvæ are very slender, and each segment but one has a deep groove round it so that it looks like two segments. They are found in various situations, (*e.g.*, under carpets and in decaying fungi), and are supposed to be predaceous, but little is known about them. They are much like the larvæ of *Therevidæ*. We figure a specimen of *S. indicus* which was bred from a pupa found in decaying wood at Pusa.

PLATE LXIII.—BOMBYLIIDÆ, ASILIDÆ, ETC.

Fig. 1. *Bombylius orientalis.* x 2
,, 2. *Argyramœba aperta.* x 2 Bombyliidæ.
,, 3. *Exoprosopa flammea.* x 2
,, 4. *Systropus himalayensis*, Bru. x 2
,, 5. *Promachus rufipes.* x 2
,, 6. *Allocotasia* (*aurata*, Fab.?) x 2 Asilidæ.
,, 7. *Laxenecera flavibarbis.* x 2
,, 8. *Phycus brunneus.* (Therevidæ). x 2.
,, 9. *Psilopus* sp. (Dolichopidæ). x 2.
,, 10. *Scenopinus indicus.* (Scenopinidæ). x 6.
,, 11. *Sp. incert.* (Cyrtidæ). x 4.

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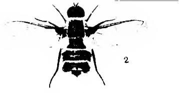

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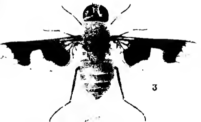

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THEREVIDÆ.

Medium-sized bristly or hairy flies. Head broad. Eyes contiguous in the male. Antennæ short, 3rd joint simple usually with a terminal style. Ocelli present. Five posterior cells, anal cell closed near the margin.

Therevids are probably predaceous both in the larval and adult condition. The larvæ, like those of Scenopinids, have the appearance of possessing 19 segments, and in Europe have been found in rotten wood and in earth. The pupæ are free. The adult flies, which are often clothed with silvery grey fur, may sometimes be seen sitting about on twigs and leaves apparently waiting for their prey after the Asilid manner: though a good deal like Asilids in appearance, they are rather more slender and have much thinner legs (fig. 392), while their attitude while waiting (for prey?) is rather different, the head being held higher and the tail depressed; the proboscis, too, is not horny and prominent as in *Asilidæ*. Nothing seems to be known regarding the kind of insects on which they most usually feed, or of the life-histories of the Indian forms. They have a fondness for sitting on sand, and have more than once been seen at Pusa watching the pits made by Ant-lions, possibly in order to secure the insects entrapped therein. We have observed them dancing in great numbers in the early morning at the beginning of the hot weather at Pusa. The genus *Phycus* (Pl LXIII, fig. 8) is not uncommonly met with in the plains, but nothing is known of it, not even that it is predaceous. Unlike most Therevids it is smooth and not hairy.

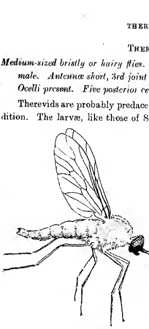

Fig. 392—THEREVA PUSA. × 5.

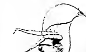

FIG 393—HEAD OF A THEREVID, FOR COMPARISON WITH ASILID.

The family as a whole includes about two hundred species: those recorded from India are some half-dozen species of *Thereva* and *Phycus*.

MYDAIDÆ.

Large or very large flies. Antennæ club-like, rather long, the 3rd joint flattened. Venation characteristic, branches of radius coalescing, and first branch of media ending at or before the tip of the wing, which is often dark coloured.

These flies have the general appearance of large Asilids, from which the above characters will be enough to distinguish them. Like the Asilids they are predaceous in both adult and larval stages, and the larvæ have been found in rotten wood. They constitute a small and widespread family of which little is known. There is one Indian species belonging to the genus *Leptomydas* in the collection of the Indian Museum. The characteristic venation is shown on Pl. LIX.

ASILIDÆ.

Antennæ 3-jointed, 3rd joint generally elongated, with or without a terminal style. Head broad, depressed between the eyes. Proboscis stout, sharp and horny. Body generally long, with strong bristles, often hairy. Legs and feet strong, pulvilli usually large, empodia bristle-like. Squamæ rudimentary or absent. Five posterior cells, of which the 1st and 4th may be closed. Anal cell open or closed. Genital organs usually conspicuous.

A very large family whose members are abundant in the plains, and may considerably benefit us by their extraordinary appetites. They prey upon other insects of many kinds and their voracity is amazing. They do not fly much, but may be seen lying in wait for their victims on twigs and stubble or leaves, generally near the ground, and their short flights produce a rather loud dull buzz. Prof. Poulton (Trans. Ent. Soc., 1907) has made a study of the food of predaceous insects, and has found that *Asilidæ* prey chiefly on Hymenoptera, Diptera, Coleoptera, and Lepidoptera, and less frequently on Orthoptera, Neuroptera, Homoptera and Hemiptera (in India Asilids feed extensively on *Oxya*

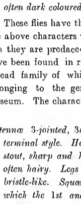

Fig. 394—HEAD OF AN ASILID, SHOWING DEPRESSION BETWEEN THE EYES.

velox, an orthopteron.) There is a large field for interesting work on these lines in India, and the student should consult Prof. Poulton's paper. Some of the Asilids are very large, and several (especially the *Laphrinæ*) look much like bees, having a comparatively short and thick body (Pl. LXIV, fig. 7); others (*Leptogaster*, fig. 395) are of the most slender build, with a very long thin abdomen, and no pulvilli on the feet. These are not uncommon in the hills, and the prevalence of this elongated body-form, not in this family alone but in others also, seems to be a characteristic of the flies of that region as compared with those of the plains. Why this should be is at present an unanswerable question. In the case of the Bombyliid *Systropus* (Pl. LXIII, fig. 4) the strong resemblance which it certainly has to long-bodied Hymenoptera common in the same locality may very possibly be of benefit in some way; we do not know in what way. The same might perhaps be said of the elegant little Syrphids of *Baccha*, *Sphegina*, and allied genera (Pl. LXV, fig. 4), but not of *Leptogaster* since this is not like any common Hymenopteron, and in this case some other explanation must be sought. Perhaps the requirements of their larval stages are not fulfilled in the plains; perhaps the large surface exposed on the long abdomen is uncomfortable in very hot dry conditions; it may be that the flies prey especially upon certain species of insects which occur in abundance only in the hills, or they may have some parasite or other enemy which lives only in the plains. These are, of course, the merest suggestions, and entirely valueless, as all such speculations must be until backed up by adequate knowledge of the life-histories and physiology of the insects. In one respect we may say with some certainty that the attenuate shape of *Baccha* and *Leptogaster* is of advantage, and that is as a protection, at any rate from human enemies, for unless shown up by a light background they are very noticeably inconspicuous. Another point which is perhaps worth notice is the strong likeness in form and general build between *Leptogaster* and Dragon-flies. It is probable that this superficial likeness in two such distantly

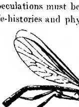

Fig. 395.—An Asilid (Leptogaster) Simla.

connected groups has arisen independently in response to the requirements of their common mode of life. Both the Asilid and the Dragon-fly live by chasing other insects and catching them on the wing, the former sucking their juice with its pointed beak, the latter chewing them in its powerful jaws. Both have a particularly broad head furnished with large eyes; strong bristly grasping legs and feet, large wings and a long thin abdomen. The utility of strong mouthparts, legs and wings is obvious; the breadth of the head probably gives its owner greater powers of judging the distance of its prey correctly, while the long abdomen helps as a balancer and rudder, enabling the insect to turn quickly and accurately when swooping on its victim.

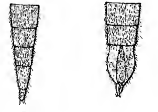

Fig. 396—The extremity of the abdomen in female and male Asilids.

The sexes are easily distinguished; the males always have big claspers and the females a pointed ovipositor (fig. 396). The larvæ are probably all predaceous, and with the pupæ are most often found in rotten wood (fig. 397) or in earth. The full life-history is not known for any Indian species.

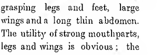

Fig. 397—Larva of Asilus, after Brauer ×2.

The family comprises some 3,000 known species of which over a hundred are recorded from India. It may be divided as follows :—

(a) Marginal cell closed.
  (1) Antennæ with terminal bristle .. *Asilinæ*.
  (2) Not with terminal bristle .. .. *Laphrinæ*.
(b) Marginal cell open.
  If without pulvilli, and with slender abdomen .. .. .. *Leptogaster*
  Otherwise .. .. *Dasypogoninæ*.

The number of genera is large, and the generic characters often difficult to distinguish.

EMPIDÆ.

Generally small flies with distinct neck and small round head with a projecting horny proboscis. Eyes often meeting in the male. Antennæ 3-jointed, 3rd joint usually with a terminal style. Squamæ very small or absent. Legs often spined or thickened. Pulvilli long. Venation variable, anal cell often very short owing to the turning back of the 2nd branch of the cubitus.

This is a rather large family of predaceous flies with apparently few species in the plains In their mode of life and often in general appearance they are like the *Asilidæ*, but (excluding hill and forest areas) the latter are in India distinctly the dominant group, the reverse of what is the case in Europe, where the Empids fill the same place in nature as is occupied in the Indian plains by the very abundant Asilids of that region: they are as a rule slenderly built, with a rather long thin abdomen; in habit they are somewhat more purely aërial than are the Asilids, and have usually very good control over their flight. They are also much less bristly and hairy than *Asilidæ*, while their eyes have no deep furrow between and are closer together. (Osten Sacken associates the absence of large bristles and presence of large eyes with aërial habits: *i.e.*, a being characteristic of fliers rather than walkers.) Some of them suck flowers as well as the juices of insects, and they appear to prey far more exclusively upon other Diptera than do the *Asilidæ* (Poulton); with this their weaker build may have something to do.

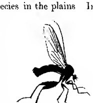

Fig. 398—EMPID (HYBOS SP.) SIMLA ×3.

The sexes are easily distinguished, as the genital organs are usually quite clearly distinct in structure in the same way as in *Asilidæ*. Both sexes indulge at times in aërial dances, which seem to be connected in curious ways with the sexual relations of the insects (Howlett, Ent. Mo. Mag., 1907: Hamm, *ibid.*, 1908 & 1909); the study of these aërial dances has been neglected but it is certain that it would reveal many points of interest.

The life-history is not known for any Indian species but in Europe the larvæ are generally found in earth or under decaying leaves.

etc. They are probably predaceous and are described as cylindrical, amphipneustic with a prominence below the posterior pair of spiracles. The pupæ are free. In the plains, as mentioned above, the species seem to be few in number, though individuals (especially *Tachydrominæ*) are often common, but they occur in fair abundance in the hills. This may be due to the lack of shade and moisture in the plains not suiting them, for in England they are found most often in rather damp places, such as meadows bordering on running brooks or in shady woods. They are sometimes rather difficult to identify, owing to their considerable variety of form and venation. Van der Wulp lists one species of each of the genera *Hilara*, *Pterospilus*, and *Hybos* as Indian. Species of the latter genus are quite common in the hills and can be recognised from the exaggerated development of the hind legs (fig. 398).

DOLICHOPODIDÆ.

Small slim flies, generally of metallic colours, with long thin legs. Antennæ often apparently 2-jointed. Proboscis short and fleshy. No squamæ. No cross-vein between discal and 2nd basal cells. Male genital organs frequently conspicuous.

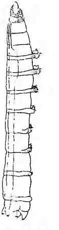
Fig. 399—LARVA OF DOLICHOPUS (*After Brauer.*) × 16

These beautiful little flies are found as a rule in moist leafy places, and in the rains may commonly be seen on hedges, garden-bushes, etc., flying nimbly about and settling on the leaves; they are often easily recognised by their elegant form and bright metallic green colour (Pl. LXIII, fig. 9). The first two joints of the antennæ are usually quite short, the second being sometimes too small to be noticeable, and the third is generally oval, but in some genera is much elongated. It bears a dorsal or terminal arista. The wings in several genera are clouded or have dark markings. The thorax is flattened from side to side, and has regular rows of bristles along the back. In keeping with the dandified appearance of these flies are the remarkable structures often found in the male, apparently for the purpose of impressing the opposite sex. and taking the form of curious elaborations of the feet, head and wings.

The sexes are easily distinguished, apart from these ornamental characters, by the form of the genital organs, the male claspers being very large and complex, generally pointing forwards and lying along the under side of the abdomen : since the sexes of the same species often differ a good deal in general character it is advisable to take every opportunity of securing male and female together when found pairing. As a rule the metallic coloration of these flies renders their identification easy, but a good many forms lack this distinguishing mark and are dully coloured. In these cases they are very apt to be confused with some of the Acalyptrate Muscoids, especially the *Ephydridæ*, whose general characters are often curiously similar. These, however, lack the rows of thoracic bristles, and the venation of the wings is usually slightly different, the 1st basal cell being longer than in the *Dolichopodidæ*. The head and mouth in the Ephydrids is also generally larger, and they have not the row of bristles round the hind edge of the eye possessed by Dolichopodids. Both families are predaceous, and both favour damp situations. Ephydrids are commonly found walking on the surface of water, and some Dolichopodids are also able to perform this feat Both groups contain species in which the front femora are thickened and armed with spines on the under side.

This striking likeness would seem to indicate some close genetic relationship, but this is improbable if we accept the principles of classification in general use. and it is more likely that the resemblances are due to the similar mode of life of the two groups : either the surroundings and habits of the insect influence its form in some unexplained way. or a certain pattern is found to pay best in these surroundings. and the variations in the direction of this pattern have become perpetuated. Very little is known of the life-history. The larvæ (fig. 399) are amphipneustic. slender and cylindrical, and live in the exuding sap or under the bark of trees. or in decaying vegetable matter. Their diet is uncertain. The pupæ are generally free : their abdominal spiracles are very small, and the breathing is done through two long horns which bear the thoracic spiracles.

The economic importance of the family in India is slight. They are predaceous, and perhaps therefore to be encouraged

The family reaches its maximum abundance in temperate regions, and two or three hundred species are already known from Europe and N. America. In India *Psilopus* seems distinctly the dominant genus and its members are in some districts extremely common on broad leaves. Van der Wulp includes seven *Psilopus* and two *Dolichopus* in his list. A species of *Psilopus* is figured on Pl. LXIII.

PHORIDÆ.

Small flies, generally black or yellowish. Head small with bristles pointing backwards, antennæ very short with long arista. Thorax much rounded and hunched. Wings sometimes large, sometimes small, with characteristic venation. Coxæ and hind legs rather long, hind femora often flattened or enlarged.

These small hump-backed flies are often seen running about on leaves or windows, and are very common all over India, though perhaps less abundant in the plains than in the hills. The venation is peculiar (Pl. LIX) and the real systematic position of the family is in doubt. The eyes are wide apart in both sexes, but the abdomen of the female is generally more or less pointed, while that of the male is more often swollen at the end. The larvæ (Pl. LXV, fig. 10*a*) are rather flattened, often with pointed processes, and sometimes a breathing-tube at the tail end: they are found in all sorts of decaying matter and are also occasionally parasitic on living insects or their larvæ. One species, *Phora*(?) *Cleghorni*, is said to have been found as a parasite on *Trycolyga bombycis*, a Tachinid fly, which is itself a parasite on the true silk-worm *Bombyx mori* (I. M Notes). Several curious wingless Phorids have been recorded as living in ants' nests in various parts of the world (fig. 402). The pupa has two thoracic breathing-processes or tubes which protrude from the old larval skin within which it lies enclosed (fig. 401).

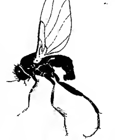

Fig. 400—TRINEURA ATERRIMA (SIMLA) × 8. (AFTER BRUES.)

This small family is useful in the scavenging way, and it is necessary for the student to be familiar with the flies, since the larvæ breed in almost any situation where they can get decaying vegetable matter, and owing to this they are often mistaken for pests, because they may have been found feeding on a damaged plant: in reality the mischief was done by some other insect and the Phorid larvæ have merely come in afterwards to clear off the remains.

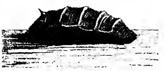

Fig. 401—PHORID PUPA FROM A DEAD COCKROACH × 16.

The European *Phoridæ* have been monographed by Becker (Abh. Zool-Bot. Ges. Wien., Vol. I, 1901), and more recently the whole family has been dealt with by Brues (Gen. Insectorum. Phoridæ). The latter includes the following six species as Indian: there are certainly many more.

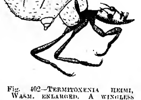

Fig. 402—TERMITOXENIA HEIMI, WASM. ENLARGED. A WINGLESS PHORID INHABITING THE NESTS OF TERMITES IN INDIA.
(*After Brues.*)

Aphiochæta	*apicalis*.	Brues.	Bombay.
,,	*limbata*	,,	India.
,,	*tibialis*	,,	,,
,,	*pulicaris*	,,	Asia. (?)
Chonocephalus	*similis*	,,	India.
Termitoxenia	*heimi*	Wasm.	,, (in termites' nests).

LONCHOPTERIDÆ.

Small flies, with short antennæ. 3rd joint simple, with a terminal arista. Wings shaped like a leaf or spear-head. Venation characteristic (fig. 401).

These little flies all belong to one genus (*Lonchoptera*). They are common in England about the grassy margins of brooks, but little is known of their life-history, which appears in some respects peculiar. They look rather like some of the small Acalyptrate Muscoids, but the shape of the wings and a comparison of the venation (fig. 403) will separate them.

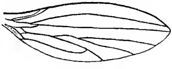

Fig. 403—LONCHOPTERID WING.
(*After Comstock.*)

They are of no economic importance, and have not yet been found in India.

CYCLORHAPHA ASCHIZA.

SYRPHIDÆ.

Small to rather large flies, often brightly coloured, sometimes furry, never bristly, usually polished. Male eyes often touching, always closer together than in the females. A "false vein" nearly always present between Radius and Media.

From an æsthetic point of view this entirely beneficial family is perhaps the most attractive of all from the beauty and diversity of form and colour represented among its members. Something like three thousand species are known from all over the world, but Van der Wulp records only sixty-seven from India, a number which very inadequately represents the truth, as the flies are abundant in the hills, though in the plains the species are often rather noticeably few. This is probably owing to the comparative scarcity of flowering plants, since the Syrphids are essentially flower-flies; in gardens one may see them at any time when the sun is shining, with their smooth polished bodies, surrounded by an aura of quivering wing, poised motionless above a flower. If disturbed, they vanish in an instant only to reappear hovering in some other spot, and this mastery of flight is very characteristic of the family as a whole, earning them their English name of "Hover-flies."

Though the mode of life of the adults of different species is very uniform (they all feed on the pollen or nectar of flowers), the habits of the larvæ are equally diverse. A few live in stems or bulbs, and a great many in rotting vegetable or animal matter; the larvæ of the genus *Eristalis* and others live in water or submerged in wet filth, and have

PLATE LXIV.—LIFE HISTORY OF SYRPHUS.

Fig. 1. Egg.
„ 2. Young larva. x 45.
„ 3. Full-grown larva. x 8.
„ 4. Pupa on leaf. x 6.
„ 5. Fly. x 4.
„ 6. Wheat plant.
„ 7. Egg laid among wheat aphis
„ 8. } Larvæ feeding on aphis.
„ 9. }
„ 10. Pupa.

Figs. 7, 8, 9, 10 are slightly larger than natural size.

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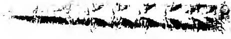

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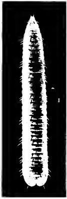

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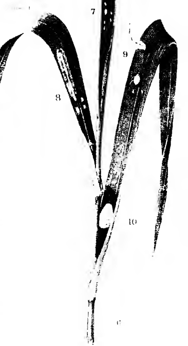

their breathing stigmata at the end of very long extensible tubes so as to reach the surface while the animal is feeding below (fig. 404); the larvæ of *Volucella* live in the nests of bees and wasps, possibly playing the part of scavengers there, and the extremely close likeness of some of the adult flies to bumble-bees is one of those facts of resemblance which lack a satisfying explanation. The very curious round flat larva of *Microdon*, the fly shown on Pl. LXV, fig. 6, similarly lives in ants' nests, but the ants have been observed to actively resent the presence of the ovipositing female. Flies of this genus are not rare in the hills, and here again the likeness to a bee found in the same locality is noticeable. The chief interest of the family economically lies in the fact that the larvæ of a number of Syrphids feed exclusively on the *Aphidæ* which do so much damage to plants of various kinds. The parent fly may sometimes be seen hovering about and laying its eggs on plants infested with Aphids. The eggs are long, oval, rather larger at one end, and are often adorned with a sculptured pattern. The larva (Pl. LXIV) has a thickish often rather transparent body tapering in front, generally with the posterior stigmata at the extremity of a short thick tubular excrescence, and a small very mobile eyeless head which moves here and there in search of food in the shape of Aphids. The creatures possess a very large appetite, and the work of destruction accomplished by them must be far from insignificant. When the larva is full grown the larval skin hardens and forms a case or puparium enclosing the true pupa, and from the head of the latter two little horns usually project through the outer case. Though the fracture of the puparium is Cyclorhaphous, it appears that these flies do not use the ptilinum to push off the top piece as do the Muscoids, and the well-marked frontal suture of the latter is not present, there being only a small triangular area above the antennæ, often quite inconspicuous, called the "frontal lunule." The pupæ of the aphis-eating Syrphids may not

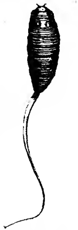
Fig. 404—PUPATING LARVA OF ERISTALIS. (× 2.)

uncommonly be found upon or under the leaves where they have been feeding, or on the earth below, and of the others also the pupæ as a rule are found at or very close to the spot where the larvæ lived. The flies themselves are easily put in their proper family owing to the presence of the "false vein" shown on Pl. LIX. Their colouring is generally rather striking, and often includes yellow bands or stripes. Many of them resemble Hymenoptera, often very closely. As mentioned above, there are a large number of genera and species in the hills, and many of these are listed by Brunetti (Ind. Mus. Rec.), while a mass of valuable information on the European species is to be found in Verrall's "British Flies," to which the student is referred.

PLATYPEZIDÆ.

Small flies, not bristly, with hind tarsi of the males enlarged or ornamented. Head as broad as the thorax. Eyes touching in the male, sometimes in the female. Two first joints of antennæ short, 3rd longer, with terminal arista. Basal and anal cells short. Posterior cross-vein sometimes absent (i.e., there may be no closed discal cell).

These curious little flies are generally looked upon as rarities in Europe, but they are not very uncommon in the plains during the rainy season, and from the fact that the larvæ appear to live in rotten fungus one would expect to find that they occur even more frequently in the hills. In the plains they may sometimes be seen running on broad leaves under trees, travelling round and round in little circles, and expending a vast amount of energy without any obvious purpose or perceptible result. In their way of moving and in their colour and general shape they somewhat resemble *Phoridæ*. The family is quite a small one, and of no economic interest. A species of *Platypeza* from Mussoorie is figured on Pl. LXVI. The student should refer to Verrall's "British Flies" for information on the European species.

PIPUNCULIDÆ.

Small flies, not bristly. Head very large and round, mostly made up of the eyes, which touch in the male. Antennæ 3-jointed, 3rd joint pointed at the end with a dorsal arista. Female ovipositor strong and prominent. Wings long. 1st posterior cell nearly closed. Basal and anal cells long, the latter closed near the margin.

The remarkably large eyes and head of this family, together with the long wings, render its members easily recognisable. Their life-history is

PLATE LXV.—SYRPHIDÆ, ETC.

Fig.	1.	*Helophilus bengalensis.*	x 2	Syrphidæ
,,	2.	*Paragus serratus.*	x 2	
,,	3.	*Lycastris albipes.*	x 2	
,,	4.	*Baccha* sp.	x 2	
,,	5.	*Megaspis crassus.*	x 2	
,,	6.	*Microsdon* sp.	x 2	
,,	7.	*Eristalis æneus.*	x 2	
,,	8.	*Pipunculus* sp. (Pipunculidæ).	x 6.	
,,	9.	*Platypeza* sp. (Platypezidæ).	x 8.	
,,	10.	*Aphiochæta* sp. (Phoridæ).	x 8	
,,	10*a*. 10*b*.	Larva and pupa.	x 8.	
,,	11.	*Conops erythrocephala.* (Conopidæ).	x 2	

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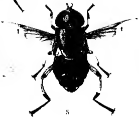
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interesting economically, as they are parasitic upon *Rhynchota* (especially *Jassidæ* and *Fulgoridæ*) in whose bodies the small thick oval larvæ live until full grown: they may then force their way out between the thorax and abdomen and fall to the ground, where they hide themselves and turn to smooth black puparia (fig. 406).

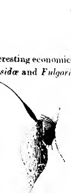

Fig. 405—ANTENNA OF PIPUNCULUS. (*After Perkins*.)

The flies themselves are generally caught by sweeping flowers and undergrowth, and though owing to their retiring habits they are not often seen they are really not uncommon in the plains, while in the hills they can be found in fair abundance when looked for.

Though they fly with none of that flashing rapidity characteristic of Syrphids and Bombyliids they are certainly not inferior to these two families in their extraordinarily accurate control over their flight, which is probably unsurpassed by any insect. When seeking their prey among grass and other herbage, their irregular and wandering flight may easily cause them to be mistaken for small Hymenopterous parasites, but their faculty of hovering in a confined space is remarkable. We have sometimes imprisoned them in glass tubes ($\frac{1}{2}$-$\frac{3}{4}$ in. wide by 3 in. long) for the pleasure of witnessing an exhibition of this power: they will repeatedly hover from end to end of this small space without apparently ever touching the glass, or will remain with the body quite motionless, suspended in the middle of the tube. According to Jenkinson (Ent. Mo. Mag., 1903 p. 222) the female poises herself thus before she darts at and seizes the victim in whose body she will lay her eggs.

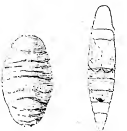

FIG. 406—PIPUNCULID PUPARIUM (×abt. 12) & DIAGRAM OF HOPPER TO SHOW POSITION OF PUPARIUM IN THE BODY. (*After Perkins*.)

In view of their specialized parasitic mode of life it is interesting to compare these flies with the *Asilidæ* and *Empidæ*, which also hunt their prey by sight. In all three families we find big eyes set in a very mobile head, small antennæ, large wings, and particularly strong legs with well-developed clawed feet; all these structures are helpful in detecting and seizing a victim. Pipunculids, however, want merely to lay eggs in their victims, while Asilids and Empids require theirs for food, and this difference in habit is reflected in the differing structure of the mouthparts, which are large and beak-like in the two predaceous families, but are extremely small and ill-developed in Pipunculids. The Pipunculid ovipositor, on the other hand, is particularly well developed, being large and strong, a sharp curved piercing organ. The family is small but widespread, comprising practically only one genus (*Pipunculus*) of any importance, and of this perhaps a hundred species are known. Kertesz catalogued the species known up to 1900 (Termesz. Fuzetek, XXIV). Becker has monographed the European forms (Dipterologische Studien V. Berl. Ent. Zeit. 1897), and Verrall ("British Flies") gives full information as to British species, while Perkins has since then described a large number of new species from Hawaii (Hawaiian Expt. Sta. Bull., 1 Pt., 4. Div. Ent., 1905) and from his paper figs. 403 and 404 are copied. Brunetti (Rec. Ind. Mus.) has described some Indian species, but little is yet known in this country of the family as a whole; they are by no means rare, and observations on their life-histories would be of much interest. An undetermined species is figured on Pl. LXV.

CYCLORHAPHA SCHIZOPHORA.

Muscoids.*

Antennæ 3-jointed, the third joint simple and bearing a bare or hairy dorsal arista. Frontal Suture present. Proboscis generally short with broad labella, sometimes pointed and horny (as in Stomoxys), occasionally absent or rudimentary (as in Oestridæ). Palpi never jointed. Never more than one submarginal and three posterior cells: marginal and submarginal cells never closed: basal cells small: 2nd basal sometimes not separated from the discal. Subcosta sometimes only indistinctly separated from R_1. The empodium small or absent.

Under the term "Muscoids" we include a vast number of flies of which the true *Muscidæ* (the house-flies and their nearest relations) form only an inconsiderable portion. The whole group is sometimes also known as Muscaridæ, Muscidæ, or as "Muscidæ *sensu lato*" (*sensu lato* meaning "in a wide sense," or "speaking broadly") as opposed to "Muscidæ *sensu stricto*," *i.e.*, the family *Muscidæ* (House-flies, etc.). The primary division of this unwieldy assemblage of species is based principally on the distance between the eyes in the male as compared with the female, the size of the squamæ, and the shape of the 1st posterior cell. This gives us two large groups. In the first the eyes in both sexes are wide apart, the 1st posterior cell is almost always quite open, and the squamæ (especially the lower squama, occasionally called a "calyptron") are generally very small or absent. These are the *Acalyptrate Muscoids*. Many of them are injurious to plants.

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* We shall speak of the sub-divisions of the Muscoids (e.g., the "*Anthomyidæ*," "*Trypetidæ*," &c.) as "families," giving them the termination "*idæ*," but it should be realised that they do not compare in definiteness of distinction with such true families as, for instance, the *Tabanidæ* or *Psychodidæ*, and it is only for convenience, because they contain so many species that they are commonly given a rank above "Sub-families."

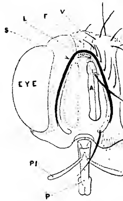


Fig. 407—Head of muscoid fly (from Townsend). V, vertex, F, front, L, frontal lunule S, frontal suture, A, third joint of antenna, Pl, palpi, P, proboscis.

In the second large group the eyes in the male are nearer together than in the female; the 1st posterior cell is almost always much narrowed or closed, and the squamæ are large and well developed. These are the *Calyptrate Muscoids*. Many of them are injurious to animals.

The view most generally taken is that the Acalyptrates represent a less highly-specialised condition than do the Calyptrates. The two groups are certainly closely related, and though the family *Anthomyiidæ* is generally included in the Calyptrates, because the squamæ are well developed and the male eyes are frequently near together, it has the 1st posterior cell quite open as in Acalyptrates, and in some other respects shows that there is no real line separating the two divisions. Because of this open 1st posterior cell, a character easily recognised, and also because many of the larvæ live after the

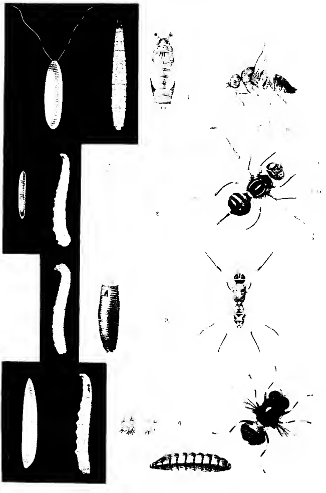
Acalyptrate manner in roots of plants and similar places, we have here included the Anthomyiids among the Acalyptrates, for the convenience of the student. Probably the family is really best placed by itself, in a distinct division intermediate between Acalyptrates and Calyptrates.

As a general rule the flies in the first big group (the Acalyptrates) are small, often very small. The extremely common little flies which are so often seen hovering about a plate of bananas or other fruit are typical Acalyptrates (*Drosophilidæ*). The adult Acalyptrate flies are usually harmless, and a large number of the larvæ are beneficial, feeding on decaying vegetables or in dung, and thus acting as scavengers. On the other hand, many of the larvæ live in the stems or fruits of plants, or are leaf-miners, and sometimes do much damage.

The flies in the second big group (the Calyptrates) are often medium-sized or rather large flies, most of them with a strong family likeness to the common House-fly or the Blue-bottle, both of which are typical Calyptrates. A large number of the larvæ are scavengers, especially the *Muscidæ* and *Sarcophagidæ*, and the maggots of both these families sometimes breed in living flesh, as in cases of Myiasis: the commonest mode of life among the Calyptrates, however. is that of parasitism, and this is practically universal among the *Tachinidæ* and *Oestridæ*. The pecuniary loss caused every year by the attacks on cattle of the larvæ of the "Warble-flies" (*Oestridæ*) must be very considerable. The ravages of the other two families are happily almost entirely confined to insects, the larvæ feeding especially on living caterpillars, and constituting an invaluable check on the numbers of the latter; only in such a case as that of the silk-worm, which forms the prey of a certain Tachinid larva, is this most useful habit to be regretted by mankind, and in this case it is mankind's own fault for domesticating the silk-worm. The few "biting" flies among the family *Muscidæ* have a very special interest in view of the part some at least of them play in spreading among men and animals diseases due to those minute blood parasites called "Trypanosomes," while the danger of infection of food with enteric and other germs, owing to the presence in kitchens and houses of flies which habitually settle on dung and other filth, though at present not fully realised, has been proved to be a real and serious one.

PLATE LXVI.—ACALYPTRATE MUSCOIDS.

1. The egg, larva, pupa and imago of *Drosophila*. Egg x 55, larva, pupa and imago x 12.
2. The egg, larva, pupa and imago of *Dacus*. Egg x 16, larva, pupa and imago x 4.
3. The larva, pupa and imago of the Rice-fly. x 5.
4. The egg, larva (with its posterior spiracles), pupa and imago of a Chloropid *(Merochlorops)* from plantain. Egg x 50, larva, pupa and imago x 8.



The classification of both Acalyptrates and Calyptrates is in an unsettled condition, as various authorities interpret in different ways the systematic value of the sub-divisions and assign them different limits. The boundaries of the "families" are of an indefinite nature, and correct identification is often a matter of very considerable difficulty. The table given below will, however, enable the student to arrange in order the majority of the Muscoids with which he is likely to meet.

ACALYPTRATES

Hymenopterous-looking flower-flies, usually of a fair size, with broad head and generally long antennæ proboscis and abdomen, the latter swollen at the end. 1st posterior cell distinctly narrowed or closed	Conopids.
Flies with very long awkward legs, long body, 1st posterior cell narrowed or closed. Wings generally with dark markings	Micropezids.
Small shiny black purple or orange coloured flies with narrow waist, generally found near excrement. Wings often with a spot	Sepsids.
Eyes on horn-like projections	Diopsids.
Small bare flies with thickened femora and very large scutellum	Rhopalomerids.
Look like Chrysomelid beetles	Celyphids.
Small sea-shore flies with flat horny thorax and bristly head	Phycodromids.
Small dung-flies with 1st hind tarsal joint flat and shorter than the 2nd, and with characteristic venation	Borborids.
Small decay-flies with arista plumose on the upper side (generally with only a few long hairs). and the lowest bristle on the front pointing downwards	Drosophilids.

Not as above.

A.—Sub-costa entirely absent or incomplete, or not having its junction with the costa distinct. R_1

generally not reaching as far as the middle of the wing.

1. 2nd Basal and Discal cells not separated by a cross-vein.

Small generally yellowish or black flies, frequently caught by sweeping grass. Sub-costa absent. Fronto-orbital bristles and vibrissæ usually absent; anal cell absent .. Chloropids.

Small often greenish-grey or brown flies found on or near water; predaceous, mouth-opening often very large. No vibrissæ, and anal cell absent or indistinct. Fronto-orbitals frequently present. Sub-costa absent .. .. Ephydrids.

2. 2nd Basal and Discal cells nearly always separated by a cross-vein.

Small often grey or silvery flies, as a rule vibrissæ present. Aristal hairs never very long. 2nd basal and anal cell often very small, but distinct, cross-veins generally near together .. .. Agromyzids. (Geomyzids).

Often fair-sized fruit-flies, partly coloured yellow, wings with dark marks or spots. Lower fronto-orbitals present. Sub-costa turning up sharply and ending indistinctly before joining the costa. No vibrissæ or pre-apical bristles. Anal cell very often drawn out into a long point. Ovipositor rather long .. .. Trypetids.

Not very small flies. Abdomen generally black, long, oval in shape. Subcosta more or less fused with R_1: Antennæ sometimes long. Vibrissæ absent. Anal cell not drawn out into a point .. .. Psilids.

B.—Sub-costa present, distinct, ending distinctly in costa. R_1 generally reaches at least as far as the middle point of the costa.

1. Vibrissæ absent.

Wings sometimes clouded. Mostly shiny black or yellow flies. Head broad; 1 or 2 fronto-orbitals. Anal cell rounded	Sapromyzids.
Wings nearly always spotted or marked. Only upper fronto-orbitals, and no preapical bristle. Ovipositor horny. Anal cell generally more or less pointed	Ortalids.
Wings often marked or spotted. Fronto-orbital sometimes present. Preapical present. Ovipositor not horny. 2nd antennal joint generally long. Frequent damp places	Sciomyzids.

2. Vibrissæ present.

Small flies with rather long bodies, the anterior and posterior cross-veins quite near together. R_1 not reaching to the middle of the wing	Heteroneurids.
Costa with short hairs and long bristles, tibiæ with spurs and preapical bristles	Helomyzids.
Generally bristly grey or blackish flies, often predaceous and found about excrement or near water. Abdomen a little elongated, having at least 5 visible segments. No costal spine. Lower squama small, often not visible from above. Male & female eyes wide apart	Cordylurids.
Blackish, grey, or brownish flower-flies with abdomen of not more than 4 or 5 visible segments. The lower squama large as a rule, rarely hidden by the upper. Male eyes generally closer than female; arista variable	Anthomyiids.

CALYPTRATES

Arista almost always with hairs along its whole length at least on one side, basal part of abdomen not bristly	Muscids.
Arista bare on the distal and hairy on the basal part; basal part of abdomen rarely bristly	Sarcophagids.
Arista bare along its whole length, abdomen often very bristly	Tachinids.

Body nearly bare, or furry, head and face rather large, mouth-parts and antennæ very small .. .. Oestrids.

We have included *Oestridæ* among calyptrate muscoids, though they are better regarded as a separate group, originally composed of several muscoid types and now much specialised for a parasitic existence.

CONOPIDÆ.

Rather elongate flies, abdomen often with a distinct waist, the tip sometimes thickened and turned under. Head large and broad, the eyes well separated in both sexes. Antennæ 3-jointed, prominent, with a dorsal arista or a terminal style. A slender, often jointed, proboscis. wings often coloured ; anal cell closed ; 1st posterior cell closed or nearly closed.

The *Conopidæ* are unlike most of the other acalyptrates in having the 1st posterior cell often closed, and partly for this reason they are frequently classed with the Aschiza ; they have, however, a ptilinum and frontal suture which indicates that they are really Schizophora.

These flies are usually fairly large, and are found about flowers, where they are easily mistaken for Hymenoptera. Their bodies are usually devoid of bristles or noticeable hairs, but often bear a glistening coat of short golden pubescence, and are frequently coloured rather conspicuously with yellow, reddish brown, or black. Their flight is not particularly rapid. Economically they are of some slight interest, as they are parasitic on Hymenoptera such as Wasps and Bumble-bees, and also apparently on locusts (in America). According to Williston, the Conopid chases the bee and lays an egg upon its body during flight. The larva on hatching burrows into the abdomen of the bee, where it remains and pupates, the adult fly emerging from between the abdominal segments of its unfortunate host. As a rule the larvæ are oval and rounded, with distinct segments, on the last of which are two large round

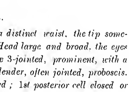


Fig. 408—CONOPID LARVA, AFTER BRAUER × 5.

stigmatic plates (fig. 408). The family is rather a small one, and its members do not seem to be very common in the plains, though more frequently met with in the hills. It is not likely that they occur in sufficient abundance to act as an efficient check on the species parasitized. A widely distributed Indian species is shown on Pl. LXV, fig. 11.

BORBORIDÆ.

Small or minute blackish or brown flies. Antennæ short, 3rd joint round, with a bare or pubescent arista. Legs rather strongly developed, hind legs with first tarsal joint broad and shorter than the second.

These flies are scavengers in the larval state, living in dung and other decaying matter. They are common in many localities in the plains as well as in the hills, and may sometimes be seen in great numbers about their breeding-places. I have caught them also in the house, where, owing to their unpleasant habits and the consequent risk of food infection, their presence is the reverse of desirable, but they do not seem to be at all common in houses, and probably this instance was exceptional. The unusual structure of the first hind tarsal joint makes them easy to recognise, and their venation also is usually characteristic (fig. 407) the veins being often short and thick and giving the wing an appearance which reminds one rather of the *Hippoboscidæ*. Otherwise the flies are generally much like the *Ephydridæ* in colouring and general shape. There are certainly many species in India, though Van der Wulp includes only one (*Limosina punctipennis*, Wied.) in his list.

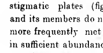


Fig. 409—WING OF BORBORID. (× 12.)

AGROMYZIDÆ.

(Including Geomyzidæ). Small or very small flies generally blackish, grey, or silvery. Front broad with or without bristles. Antennæ short, arista bare or pubescent (absent in Cryptochætum, sometimes plumose in Geomyzidæ). Anal cell present; cross-veins often near together, posterior cross-vein sometimes wanting. Vibrissæ generally absent in Agromyzidæ, generally present in Geomyzidæ.

These little flies are often difficult to distinguish from those of neighbouring families, especially the *Chloropidæ* and *Drosophilidæ*.

All three families are very abundant in India.

The larvæ are typically leaf-miners or live in stems, but have also been found in the galls of other insects, while some of them probably live in fungi, and one Indian species of the genus *Leucopis* is known to be predaceous, feeding on scale insects. They are, like most of the larvæ of Acalyptrates, small white maggots with horny mouth-hooklets but no definite head, the body rather thick at the hind end and tapering to a point in front. Some very common and beautiful flies of this family may often be seen hovering like little silver fairies in and out of the shadow of tree-trunks. They have the abdomen greyish white and shining, like metallic silver (Pl. LXVII, fig. 1), and have been bred from larvæ found in stems of Gurur.

There are three Agromyzids which are known to be important to the agriculturist; they are the Tur-pod fly, the Pea-stem fly, and the Cruciferous Leaf-miner. The Pea-stem and Tur-pod flies are figured on Pl. LXVII, figs. 2 & 3. The latter is a very black little fly whose eggs are laid in the setting flowers of Tur (*Cajanus Indicus*). The larvæ on hatching eat their way into the green seeds, forming a ring-like track round the seed, and after about a week they pupate within the pod, generally outside the seeds; the fly emerges in a few days, the whole life-history occupying a fortnight or less. Affected pods usually have a somewhat twisted and distorted appearance (fig. 409). A slender blue-green hymenopterous parasite attacks the fly, but to what extent it is effective as a check is not yet known. The Pea-stem fly is very similar in general appearance to the Tur-pod fly but is dark metallic green in colour. The larvæ, which are of the usual type, attack the stems of young pea plants at a point level with

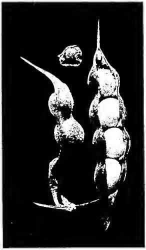


Fig. 410—Pods of Cajanus Indicus affected by the Tur-pod Agromyza. A puparium is lying at the top of the right-hand pod.

the surface of the ground, causing the plant to wilt and the stem to decay. No parasites have been found, and collection and destruction of affected plants as soon as possible after the pest is first observed is the only generally applicable remedy. Owing to the short period occupied by the life-history early action is necessary if it is to be of any use. The larvæ of a third fly, the Cruciferous Leaf-miner, as the name indicates, mine the leaves of Cruciferous plants: the flies belong to the sub-family *Geomyzinæ* (often separated from the Agromyzids as a distinct family *Geomyzidæ*) and are grey, somewhat bristly little flies with large wings. They are of less importance than the Tur-pod and Pea-stem-flies (fig. 411).

An Agromyzid (*Cryptochætum*), remarkable and easily identified by the absence of the usual arista on the third antennal joint, is an annoying "Eye-fly" in jungle at Pusa, but it is quite distinct from the more familiar (Chloropid) eye-fly which is sometimes so troublesome in the house: nothing is known of its habits except that it is found often sitting on stems and leaves or in crevices in tree trunks in small groups of half a dozen or so individuals. It is perhaps noteworthy that this little fly will live, when enclosed in a corked tube, considerably longer than any other kind of fly I have ever observed.

Fig. 411.—PUPA OF LEAF-MINING PHYTOMYZA. × 2.

DROSOPHILIDÆ.

Small chubby flies often with large light red eyes. Sub-costa absent or indistinct; 2nd basal and anal cells usually not separated; anal cell small, indistinct or absent. Vibrissæ usually present; 3rd antennal joint rounded; arista plumose, the hairs generally few and long. Lowest fronto-orbital bristle often pointing downwards.

The members of this family are extremely abundant in India, and it is only necessary to expose some over-ripe bananas or other fruit in order to see them come hovering round it. The species of *Drosophila* which is commonest in Nothern India is shown in all stages on Pl. LXVI. The fly is interesting as having what is, as far as I know, the shortest life-history yet recorded for any insect with a complete metamorphosis. Though most abundant in the rains, it appears to breed all the year round. In one instance under observation the flies paired at 8 A.M. on August 31st, remaining coupled for eleven minutes, and the same evening the female laid thirty-nine eggs on some half-decayed bananas. On the afternoon of September 2nd the male fly died, and at 11-30 A.M. on the following day the female died also. The eggs had hatched during the evening of September 1st, the larvæ all pupated on the 4th and 5th, and on September 7th the flies emerged : the whole life-history may thus be passed through within a week. Such rapid multiplication not only quite explains the abundance of the flies, but affords a very instructive example of the effective working of those conditions and influences which together make up what is called the "balance of nature" and tend to prevent the too great increase of any one species of animal. We will assume that these flies have thirty broods a year, each brood consisting of forty eggs, of which all develop to maturity, half males and half females ; a simple calculation will show that at this rate the progeny of a single pair would at the end of a year reach an appalling number. If they were packed tightly together so that each cubic inch of space contained a thousand of them, they would very easily cover the whole of India, from Kashmir to Cape Comorin, from Karachi to Calcutta, with a solid cake of flies a hundred million miles thick, or would coat the whole world with a layer of insects a million miles in depth. And yet as it is we do not particularly notice them.

Owing to their fondness for fruit they are sometimes taken to be harmful fruit-flies by those who do not know their habits, but they are in reality beneficial, as they seem never to lay eggs in any but bruised or over-ripe fruit. The eggs themselves are beautiful objects, and the curious horns or processes which they possess appear to act either as breathing-tubes or as supports to prevent the egg from sinking too deep in the decaying pulp in which it is usually laid. The Indian species have not been studied ; the genera known to me at present are *Drosophila*, *Curtonotum*, and *Asteia*, the first two including most of the common forms. *Curtonotum* is very common in the hills. The fact that some

PLATE LXVII.—ACALYPTRATE MUSCOIDS.

Fig. 1.	*Balioptera argentata*	(Agromyzidæ).	x 10.
,, 2.	Pea-stem *Agromyza.*	,,	x 16.
,, 3.	Tur-pod *Agromyza.*	,,	x 10.
,, 4.	*Brachydeutera* sp.	(Ephydridæ).	x 6.
,, 5.	*Ulidia ænea.*	(Ortalidæ).	x 6
,, 6.	*Celyphus fuscipes*	(Celyphidæ)	x 6.
,, 7.	*Diopsis* (*indica?* Wstw.)	(Diopsidæ).	x 6
,, 8.	*Sepsis* sp.	(Sepsidæ).	x 6.
,, 9.	*Calobata indica*	(Micropezidæ).	x 3.
,, 10.	*Scatophaga stercoraria:* the upper figure shows the male, the lower, the female.	(Cordyluridæ)	x 3.

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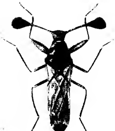

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Drosophilids breed in dung and other filth, and are fond of sitting on or near it, render them liable to carry disease germs and so infect food. The interesting discovery has recently been made that a *Drosophila* harbours trypanosome-like parasites (Chatton and Allilaire, Comptes Rendus del'Acad. Sci. Fr. 1908). Several other insects are known to harbour microscopic protozoal parasites more or less similar to those which cause various diseases of warm-blooded animals, a fact which should be taken into account in any researches on the transmission of disease through the agency of insects.

EPHYDRIDÆ.

Small greyish or brownish flies. The round mouth-opening and the head often large. Antennæ short, arista bare, or pectinate on the upper side. Anal cell rudimentary, discal and 2nd basal united.

The family, while economically of some slight importance owing to the fact that the adult flies are predaceous and abundant, is interesting because of the often curious shape and mode of life of the larvæ. These are found in decaying vegetable stuff, in dirty and stagnant water, in salt or brackish pools (sometimes in countless numbers), and even in waters so charged with alkaline salts as to be apparently uninhabitable for other living animals, the larvæ and pupæ occurring in such extraordinary abundance in this unpromising situation that they were largely used by the natives of the country for food (Williston).

As in several other predaceous insects, some of these flies (the genus *Ochthera*, which occurs throughout Northern India) have the front femora very large and flat, the lower edge being armed with rough spines which hold fast the prey, while the fly sucks its juices. Pl. LXVII, fig. 4, shows a species of *Brachydeutera* which is apparently common all over Northern India, the eggs, larvæ, and pupæ being found in tanks and puddles, on whose surface the adult flies walk about seeking the small insects on which they feed. The larvæ are vegetable-feeders, and the family is thus a distinctly beneficial one, the larvæ being scavengers, the adults insect-killers: I have seen even small Tabanid larvæ attacked and destroyed by these flies. The curious form of the pupa shows in an exaggerated degree a type similar to that exhibited by certain Drosophilid pupæ, and the *Ephydridæ* are closely related to this family. Although only three Indian species (*Notiphila fasciata*, Wied., *N. albiventris* and *N. indica*, Wied.) are included in Van der Wulp's catalogue, there are really a large number, and the remarkable forms and habits of many of the larvæ should make the study of the Indian Ephydrids an interesting one.

Becker's monograph (Dipterologische Studien IV. Ephydridæ Berlin Ent. Zeit. 1896) gives full information about this family.

CHLOROPIDÆ.

Small shining dark-coloured or yellowish flies. Head hemispherical. Vibrissæ generally absent. Front broad, sometimes with bristles at the vertex. Discal and 2nd basal cell united. No distinct anal cell. Wings and legs short. No preapical bristle on the tibiæ.

The members of this family sometimes do considerable damage in Europe and America by the larvæ burrowing in the leaves of sugar-beet or in the stems of wheat, oats, and other grain crops, while some inhabit galls on the stems of grasses. The duration of development from egg to imago is given by Howard in the case of an American Chloropid as about three weeks. The flies are common in the plains, and though stem-boring Chloropids are not yet known seriously to damage Indian cereals, cases of such damage will not improbably be found occasionally to occur. Insects of this type are extremely difficult to deal with, since if the fly once succeeds in laying its eggs nothing can save the plant. Failing the presence of efficient parasites little can be done save early removal and

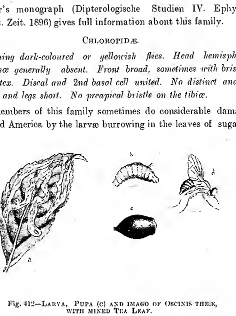

Fig. 412—LARVA, PUPA (C) AND IMAGO OF OSCINIS THEÆ, WITH MINED TEA LEAF.
(*From Ind Mus. Notes.*)

destruction of affected plants and the clearing of any neighbouring jungle or grass such as might form a breeding place for the flies. Larvæ which live in the stems of plants are naturally liable to remain unnoticed, and the effects due to their presence may be ascribed to some other cause. Some Chloropid larvæ are scavengers, living on decaying vegetable matter or on plants previously burrowed or wounded by other insects, and *Oscinis theæ* is recorded as having been found damaging tea by mining the leaves. (I. M. Notes) (fig. 412.)

One of the Indian Chloropids has a habit of hovering in an annoying manner just in front of one's eyes, and is known as the "eye-fly." It is a minute shiny dark-coloured fly, which seems to be particularly fond of clinging to hanging strings and ropes. It is not unusual to see several hundred of them on a few inches of string hanging from a "chick," and with the aid of a duster or a killing-bottle it is easy to destroy the entire swarm; in Europe members of an allied genus (*Chlorops*) are also known occasionally to congregate in vast numbers in particular chosen spots. A fly similar to this eye-fly is a serious pest in the Southern States of America, numbers of them getting into the eyes of domestic animals, and they are held in great measure responsible for the spread of a disease of the eyes which at times is extremely prevalent among children in those districts where the fly is abundant. It is said that in the Fiji Islands the spread of a serious eye disease is recognised by the European residents as being due to the agency of "gnats", against whose attacks they protect themselves by wearing veils, but to what family the "gnats" belong is not mentioned. (L. O. Howard.)

Species belonging to genera allied to *Elachyptera* and *Chlorops* are very common in India. Their antennæ are often horn-like (fig. 413) and they are coloured in some pattern of yellow and black; they can always be found by sweeping grass, in whose stems their larvæ probably live.

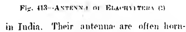

FIG. 413—ANTENNA OF ELACHYPTERA (?)

The stages of a pretty little Chloropid, belonging to a genus closely related to *Chlorops* (*Merochlorops?*) are shown on Pl. LXVI. The larva lives in the watery tissue of the swathing leaves round the stem of plantain-trees and under sissoo bark, and is remarkable for the pattern of its posterior spiracles. The larvæ of this fly were utilised by a native "doctor" at Pusa in a rather interesting way. The man has a considerable reputation in the district, due to his success in curing cases of tooth-ache and similar ills. A violent attack of tooth-ache (simulated for the occasion) gave an excuse for requiring his services. The treatment consisted in rattling a small stick round the patient's mouth; the operator's unemployed hand (closed) meanwhile rested above a cloth spread on the patient's knees; at the psychological moment the hand quietly opened and the patient's attention was then directed to the fact that the maggots which had been the cause of his pain were successfully removed and lay exposed on the cloth. The operator added that he believed one obstinate maggot still remained in the tooth, and that this would probably necessitate a repetition of the treatment at a later date. Similar but rather less crude methods are adopted by Chinese practitioners in the neighbourhood of Bombay. They pretend to suck out the maggots from the affected part, using a small bamboo tube. Through the kindness of Captain Liston and Dr. Surveyor I got an opportunity of examining some of these maggots, and found them to be Cecidomyiids, apparently from galls.

CELYPHIDÆ.

Scutellum immensely enlarged, covering the wings and abdomen. Antennæ long, arista flattened.

These insects, owing to the remarkable size of the scutellum, look very unlike flies, and have more the appearance of small round-backed beetles. The scutellum and general surface of the body is smooth, with a more or less metallic coloration, and this increases the resemblance. The structure of the antennæ and of the abdomen is also curious. The flies appear to be not uncommon in some parts of the plains and are generally found among grass. Nothing at all is known of their life-history, or of the advantages, whether protective or otherwise, of their extraordinary structure.

Four species are recorded from India, all belonging to the genus *Celyphus*. Pl. LXVII, fig. 6, represent *Celyphus fuscipes*, Mq.

DIOPSIDÆ.

Sides of the head drawn out into horn-like projections which bear the eyes. Front femora thickened.

The remarkable structure of the head makes this small family very easy to recognise. One species (fig. 414) is commonly met with in the plains, sitting about on leaves in shady places, but as in the case of the *Celyphidæ*, nothing is known of the life-history. The exaggerated distance between the eyes may very probably give the insect increased accuracy in judging distances, just as "prismatic" field-glasses give an enhanced stereoscopic effect, owing to the outer lenses being at a greater distance apart than the eyes of the user, and this accuracy might be useful if the animal were predaceous; the possibility that such may be its mode of life is also suggested by the structure of the front femora, which is similar to that seen in several predaceous flies. Fig. 414 represents the commonest species of N. India, and another species is shown on Pl. LXVII, fig. 7.

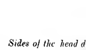

Fig. 414—DIOPSID (SPHYRACEPHALA HEARSEYANA) × 6.

PSILIDÆ.

No vibrissæ. Antennæ generally long. Lower fronto-orbital bristles absent. Abdomen rather long and thin. Legs rather long. Sub-costa absent, 1st posterior cell not narrowed. No preapical bristle on the tibiæ.

Very little is known of this family, beyond the fact that some of the larvæ live in galls or in the roots of plants. Only one Indian species is on record, and the flies do not appear to be very common, the larvæ are

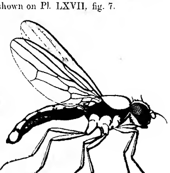

Fig. 415—PSILID BRED FROM [illegible]

slender, with the posterior spiracles dark coloured and somewhat raised.

The fly shown in fig. 415 has been reared from larvæ found in the bark of Til (*Sesamum indicum*).

SEPSIDÆ.

Head round, proboscis and antennæ usually short. Abdomen slender, narrow at the waist. Male genitalia prominent. Basals and anal cell distinct. Sub-costa present or absent.

The majority of these small flies are easily recognised by their form and colour. They are yellowish, shining black or dark metallic purplish brown in hue, and the abdomen is thin at the waist, its extremity being considerably thicker and generally bent downwards (Pl. LXVII, fig. 8). The wings often have a dark spot near the tip. The larvæ jump like those of *Trypetidæ*, by fixing their mouth-hooklets in two small notches at the tail-end and suddenly releasing them with a jerk, which may propel the animal for six or eight inches. They are scavengers, living in dung or other decaying matter, and the flies may commonly be found in abundance about these breeding-places; they have a habit of raising and lowering their wings as they walk, in a way that conveys an impression of daintiness and affectation amusing to those who know their real tastes and habits. In Europe and America, where cheeses are popular and smoked or dried meat is often stored in large quantities, flies of the genus *Piophila* (whose larvæ are known as "cheese-hoppers") often do very considerable damage to these articles of food. The larvæ and puparium are of the usual Muscoid type, the larva smooth, thick, and blunt at the tail end, and tapering away to the head, the puparium roughly the size and shape of a small brownish grain of rice, its surface rather winkled. The whole life-history occupies about three weeks or rather less.

The common Indian species mostly belong to the genus *Sepsis* (Brunetti, Ind. Mus. Records), and the flies are very common everywhere, though less so in the plains than in the hills. In any hill-station they can be found in very great abundance and would constitute a serious danger to the health of the inhabitants were they not fortunately essentially "out-door" flies. If they were in the habit of settling on food in kitchens or elsewhere, their custom of walking about on fresh dung would be sure very often to result in infection of the food with disease germs, but we have only occasionally found them numerous in and about cooking-places.

MICROPEZIDÆ.

Fairly large flies, the body and legs generally very long and slender, the face retreating in profile. Sub-costa present or absent, anal cell present. 1st posterior cell usually narrowed or closed. Wings often marked or spotted.

Very little is known about these curious and ungainly-looking flies, although a considerable number of species have been described, of which some half a dozen are recorded as having been met with in India. Nothing seems to have been known hitherto of the life-history of any member of the family, but fig. 416 shows the larva and pupa of a *Calobata* (Pl. LXVII, fig. 9), which has been bred from the decaying roots of ginger plants which had been attacked by a fungus-disease. The elongated reddish pupæ were frequently found deep in the root, lying in long tunnels eaten by the larva, and along these tunnels the imago made its way to the surface on emerging. The flies are generally found in rather damp shady places, sitting and walking about on leaves and grass-stems, and they have the habit of holding the forelegs straight out in front of the head like antennæ, somewhat as in *Chironomidæ* and some *Ortalidæ*. There is a structure on the front femora which may possibly be some kind of sense-organ and be connected with this habit.

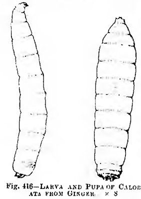

Fig. 416—LARVA AND PUPA OF CALOBATA FROM GINGER. × 8

TRYPETIDÆ.

Flies of moderate or rather small size, often more or less marked with yellow. No distinct vibrissæ. Head hemispherical, front broad with lower fronto-orbital bristles near eye-margins. Female ovipositor usually projecting. Sub-costa runs into costa more or less at right angles, and is often faintly defined near the point of junction. Anal cell distinct, its hind corner generally drawn out to a sharp point. No preapical bristles on tibiæ. Wings generally with dark markings.

Economically this is a very important family, as it includes several serious pests of fruit and vegetables.

The flies are as a rule easily recognised from the above description, the only ones with which they are liable to be confounded being the

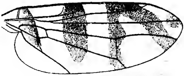

Fig. 417—Wing of Trypetid showing the indistinct Sub-costa. (*After Loew.* ×16.)

Ortalidæ. In these latter, however, there are no fronto-orbital bristles (*i.e.*, the front is not bristly all the way down the sides), the sub-costa runs into the costa at an acute angle, not a right angle, and is not indistinct at the junction. while the anal cell, though large, is often very indistinct. The family is of importance because it contains the bulk of the "Fruit-flies," whose larvæ by their presence often render uneatable the mangoes, peaches, oranges, melons, gourds and the fruits of various other cucurbitaceous plants in which they are most usually found. In other countries *Ceratitis capitata* is a very serious pest of oranges and other fruit, but does not occur in India, though an allied species has been found in the North-West and in Bombay. In this genus (*Ceratitis*) the males have on the head two long bristles with broad leaf-like tips. The ordinary Indian Fruit-flies belong to the genus *Dacus*, and there are some half-a-dozen species which have attracted notice owing to damage inflicted on fruits in various districts, the troublesome species of fly varying with the locality and to some extent with the time of year. All the commoner species of *Dacus* have a strong family likeness, being yellow or reddish yellow with more or less of dark greyish black, the dorsal part of the thorax being frequently blackish, often with yellow marking. The general type of colouring can be seen on Pl. LXVI which represents *Dacus diversus*, Coq. The life-history of Fruit-flies, speaking generally, is as follows :—the long white eggs are laid just under the skin of the fruit by means of the long horny ovipositor possessed by the female; they hatch in two or three days and the young maggots tunnel into the fruit and continue eating for a fortnight or so; they then as a rule, but not always, leave the fruit and fall to the ground, where they burrow to a depth of one to two inches and pupate, the pupal stage

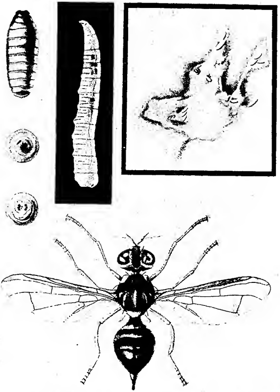

Fig. 418—The Life-history of a Fruit-fly (Dacus Cucurbitæ). The eggs (right side of figure) lying just under the skin of a gourd; of the two figures below the Puparium, the upper is the anterior end and showing anterior Spiracles, the lower the Posterior end and the Posterior Spiracles. (× 8).

lasting about a week. We have found that Citronella oil has an extremely strong attraction for the males of the destructive Peach-fly (*Dacus persicæ*), and that this is probably due to the females having the same smell, which we have ascertained to be the case. Details as to habits and the periods of the different stages vary in different species. The larvæ (Pl. LXVI and fig. 418) are of the type usual among Acalyptrates, blunt behind with rather conspicuous stigmata. and tapering to the head end which is provided with black mouth-hooks. the anterior stigmata showing as a curved row of ten or a dozen small bead-like rounded projections. The colour of the larva is dirty whitish or pale yellow, and the skin is smooth and shining, the longitudinal tracheæ usually clearly seen beneath it. The larvæ can hop in the same way as Sepsid larvæ by fixing the mouth-hooks in a notch just below the anus and then uncurling the body with a sudden jerk. Preventive measures consist of various devices to protect the fruit from the ovipositing female, such as netting, earthing up the young fruit, or protecting them with paper screens until the skin has grown thick and tough. Remedial measures are useless unless begun in the earliest stages of an attack, and consist of the prompt destruction of all affected fruit by boiling, submerging, or burying the fruit at least eighteen inches below the surface of the ground and firmly stamping down the earth with which the hole is filled in. Though most if not all the *Trypetidæ* pass their larval stage in the fruits, stems, or leaves of plants, the two genera. *Dacus* and *Ceratitis* (the latter a genus with banded wings, the thorax and base of the wings spotted with black, which has been recorded as damaging oranges in North Bombay), seem to comprise all the species at present known to rank as real pests. The bulk of the species of *Trypetidæ* are a good deal smaller than the fruit-flies, and are generally greyish in colour with beautiful iridescent eyes and prettily-spotted wings. We have seen representatives of the genera *Trypeta*, *Urellia*. *Urophora*, *Tephritis* and *Rhabdochæta*, but the Indian members of the family as a whole have yet to be worked out, and there are probably many genera. The student of *Trypetidæ* will find most information in the various writngs of Loew, especially "Die Europaischen Bohrfliegen," and the "Monographs on the Diptera of N. America" published by the Smithsonian Institution.

ORTALIDÆ.

Rather small but not minute flies, the body generally smooth and shiny, the wings nearly always marked with dark bands or spots, the sub-costa distinct and meeting the costa at an acute angle, not as in Trypetidæ. Anal cell indistinct. The front broad, not bristly all the way down the sides. Female ovipositor prominent and horny. Tibiæ without preapical bristles, only the middle pair with spurs.

This family contains a number of species of diverse form, and some of them much resemble *Trypetidæ* in appearance. Little is known of their life-histories, but it seems probable that these are of the same type as those of *Trypetidæ* and *Chloropidæ*, that is to say, most of the larvæ are likely to inhabit the leaves and stems of plants, though some may breed in decaying matter : they are not yet known to be of economic importance in India. One of the commonest species in this country is that figured on Pl. LXVII. fig. 5. *Ulidia ænea*, F., a beautiful little fly of shining blue-green and copper colour which may often be seen sitting basking on leaves and slowly raising and lowering its forelegs one after another, as though it were delivering a weighty discourse on some serious subject. The reason for this curious habit is unknown, but it suggests that the fore leg might have some sensory function and serve as a kind of auxiliary antenna. This particular species is unlike most Ortalids in having unmarked wings, the banding and spotting of the wings being very characteristic of the family as a whole. Indian *Ortalidæ* still require to be worked out from the systematic point of view. The more important genera are *Rivellia*, *Ortalis*, *Ulidia*, and *Loxoneura*. For details Van der Wulp's catalogue may be referred to, and for further descriptions the writings of Coquillett (Proc. Ent. Soc., Washington, VI) and Kertesz (Tijdsch. V. Entom. XXIII, and Termes. Fuzetek., 1897).

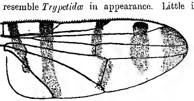

Fig. 419—WING OF ORTALID (COMPARE WITH FIG. 417) × 16.

SAPROMYZIDÆ.

Small rather short-bodied flies usually shiny and coloured blackish blue or yellow, the female with a rather long slender ovipositor. The head as broad as the thorax, third joint of the antennæ generally large and fairly long. Wings often clouded.

As their name implies the larvæ of this family feed on decaying matter, and are usually found in rotten vegetable stuff. Little is known about the Indian species, but fig. 420 represents a fairly common blue-black *Lonchæa* sometimes seen sitting on leaves in the neighbourhood of excrement. Species of the other chief genus of the family, *Sapromyza*, also occur in India, but do not seem to be common. For Asiatic species the writing of Kertesz (Tezmeszetraji Fuzetek, Vols. XX—XXIII) and Czerney, Genera Insectorum, *Lauxaninæ*, may be consulted.

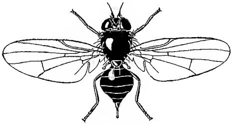

Fig. 420—LONCHÆA, PUSA. × 12.

HELOMYZIDÆ.

Small flies of greyish or yellowish colour. The antennæ short, the third joint rounded. Wings large with distinct basal cells and the costa usually bristly.

The flies of this small and unimportant family deposit their eggs in decaying vegetable matter and in the dung of various animals, including that of bats living in caves. Van der Wulp lists one species, *Helomyza maura*, Wlk., from "East India," and we have taken a *Tephrochlamys* at Allahabad, but otherwise we know of no record of any Indian species.

SCIOMYZIDÆ.

Sub-costa distinctly separate from Radius. Wings rather long, usually with dark markings. No vibrissæ. Head rounded, often broader than the thorax. Preapical bristles on tibiæ.

Little is known about the habits and life-histories of the members of this family but they do not seem to be of any economic importance. They are mostly small sluggishly-moving flies, found in damp grass or in the neighbourhood of water, the body often coloured dirty brown and wings much spotted with dark brown. The abdomen is often rather long, and has six segments visible. The larvæ are mostly aquatic, feeding on water-plants. One genus *Sepedon* (see Brunetti. Ind. Mus. Records) is conspicuous and unlike those whose general appearance is described above (fig. 421). Most of these latter belong to the genus *Tetanocera* and constitute the bulk of the family, which has been monographed by Hendel (*Sciomyzidæ*, Verhand. Zool. Bot. Ges. Wien., 1902). About a hundred and fifty European species are known: the known Indian species belong to the genera *Dryomyza, Sciomyza, Tetanocera,* and *Sepedon*.

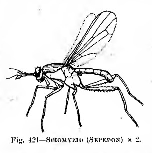

Fig. 421—SCIOMYZID (SEPEDON) × 2.

PHYCODROMIDÆ.

Small dark-coloured flies, the whole body noticeably flattened. Face and front very bristly. Preapical bristle on all the tibiæ. Sub-costa distinct; basals and anal cell present.

These curious little flies all live on the sea-shore, generally among the line of sea-weed and other refuse left by the high tide. Their larvæ are presumably scavengers, but I do not find any reference to their life-histories. The adult flies have a slight superficial resemblance to small *Hippoboscidæ*, owing to their flat shape and stout legs, and perhaps to some *Borboridæ*, but these are hardly likely to be confused. There are only about a dozen European species, but the individuals are often very numerous in the abovementioned localities. None are recorded from India.

HETERONEURIDÆ.

Small rather slender flies, with vibrissæ. R_1 and anal veins short; sub-costa not very distinct, cross-veins quite close together.

A small and unimportant family. No Indian species have been bred, and the flies are uncommon. In Europe the larvæ have been found in decaying wood and the flies occur in rather damp shady places. One species has been seen at Pusa.

CORDYLURIDÆ.

Sub-costa distinct, costa not bristly at its end. 1st posterior cell not narrowed. Two basals and anal present. Head rounded, the eyes round and bare, the front broad in both sexes. Abdomen with at least five visible segments. Squamæ small.

This family, with the *Anthomyiidæ*, is transitional between the Acalyptrates and the Calyptrates. To the *Anthomyiidæ* it is very closely related, and with some species it is most difficult to decide in which family they should be placed. The chief difference is that the Anthomyiids have the eyes usually closer together in the male than in the female, while both sexes of the Cordylurids have the eyes wide apart, and in them the structure of the genital organs affords the best means of distinguishing the sexes, the males usually having the abdomen blunter and more rounded than the females. Contrary to what is usually the case, the males of some Cordylurids (e.g., *Scatophaga*) are very considerably larger than the females. Many of the flies breed in dung. These are chiefly the *Scatophaginæ*. The other genera are usually found in wet places near ponds or tanks, and several of their larvæ live in the stems of water-plants, while one genus *Clidogastra* has occurred as a parasite in a Noctuid caterpillar (Williston). The larvæ are variable in structure, but those of *Cordylurinæ* are amphipneustic with both pairs of stigmata conspicuous. Little seems to be known of the life-histories and they have not yet been studied in India, with the exception of the Cordylurid figured on Pl. LXVI, the "Rice-stem fly." The larva and the characteristically truncated pupa are sufficiently described by the picture. The fly differs from most allied *Cordylurinæ* in having no conspicuously large bristles on the mesonotum (dorso-central bristles). The larvæ live in the stems of young rice and pupate there; mature stems are rarely or never attacked: the wilted-looking rice-stems which harbour the larvæ are easily pulled out from the ensheathing leaves, and then present the appearance of having been chewed in the mouth. As is the case with all stem-flies, no effective remedy has been discovered: while the fly frequently does considerable damage to the young rice, it is by no means a specific pest of this crop, but has apparently very varied habits. It has been bred from rice, sorghum, maize, millets, cheena (*Panicum miliaceum*), sama (*P. frumentaceum*), celery, khira (*Cucumis sativus*) and brinjal, from wheat, which it damaged considerably in the neighbourhood of Harnai (Baluchistan) 1909, and also from rotten potatoes and decaying vegetable matter of various kinds. This would point to the possibility of its occurring in rice only after the stem had been otherwise damaged, but such is not the case. Except for the Rice-stem fly, the family is on the whole a distinctly beneficial one, for not only do the larvæ eat up dung and other unpleasant substances, but many of the adults are predaceous, and like most predaceous flies possess large appetites. In the hills at Mussoorie I have found *Scatophaga* very common, especially about excrement, and the common species (*S. stercoraria*, which occurs also in Europe) is very conspicuous from the yellow woolly hair with which the male is covered. (Pl. LXVII, fig. 10.) I have not met with *Scatophaga* in the plains, but *Hydromyzinæ* occur there as well as in the hills, and may be seen in company with Anthomyiids, Ephydrids and Dolichopodids, hunting for prey on the edges of well-puddles, the mud of tanks and rivers, and even in the spray of waterfalls. Their victims are sometimes small drowning flies, and often aquatic larvæ (including those of Mosquitos and Tabanids) which they will not unfrequently even drag from the water to devour at leisure on dry land. The flies are generally difficult to catch, as they fly very nimbly and close to the mud or to the surface of the water.

The table of sub-families is abridged from Becker's monograph of the family (Dipterologische Studien I. *Scatomyzidæ*. Berlin. Ent. Zeit., 1894) in which he enumerates 125 European species.

1. Scutellum with at least four bristles;
   wings generally long. If short, then
   the abdomen unusually long .. 2
   Two to four scutellar bristles. Wings
   generally short and rounded .. 3

2. Head broad. Palpi spoon or leaf-shaped .. *Hydromyzinæ.*
Head rounded, not particularly broad. Palpi not broadened .. .. *Scatophaginæ.*

3. Front femora with a double row of bristles on the inner side .. .. *Norellinæ.*
Front femora with at most a single row of bristles on the inner side 4

4. Face short. Palpi small without long bristles. Antennæ short, arista bare or at most pubescent .. .. *Clidogastrinæ.*
Face long. Palpi only occasionally flattened, sometimes with long end-bristles. Arista bare or plumose. Mostly very bristly flies .. .. *Cordylurinæ.*

ANTHOMYIIDÆ.

Not large flies; coloured dull brownish black or grey, the squamæ fairly large, and the eyes usually closer together in the male than in the female. The 1st posterior cell widely open. The abdomen with four or five segments visible, rarely bristly.

The division of Calyptrate Muscoids is usually made to include this family, while some authors make the Anthomyiids into a separate division intermediate between Calyptrates and Acalyptrates: this is probably their natural position, but we have for convenience included them in the Acalyptrates after the *Cordyluridæ*, to which they bear very close relationship. The adult flies are generally very much like house-flies in colour and general appearance, and one genus, *Homalomyia*, habitually haunts human habitations in India in company with the true House-flies (*Muscidæ*). All the *Anthomyiidæ* are flower-flies with the exception of a few predaceous species, but their larvæ are of somewhat diverse habits, a few being found in dung, others in decaying vegetable matter of different kinds, and others in the roots of plants. Though the last-named group are often very destructive to onions and other crops in Europe and America, and very difficult to combat, no instances of their having done noticeable damage in India have yet come to our knowledge. The eggs, larvæ and pupæ are of the usual muscoid type, the larvæ similar in proportions to those of fruit-flies (fig. 418) and as a rule having the posterior stigmata well marked. In root-inhabiting species the larvæ may remain in the root when pupating or may come out and pupate in the soil near by. The Indian species have not been recently studied, and will probably be very largely increased in number, as the family is a large one. Dr. P. Stein is regarded as the chief authority on Anthomyiids, and his various writings, together with Meade's "British Anthomyiidæ," should be consulted for information as to the separation of the numerous genera. Van der Wulp lists about twenty Indian species; of these one of the commonest and most noticeable is *Limnophora tonitrui*. Wied., a little fly of the size of a house-fly, with a light grey thorax marked with conspicuous blots of velvety black. The chief genera at present known to occur in this country are *Spilogaster*, *Ophyra*, *Limnophora*, *Anthomyia*, *Homalomyia*, *Lispe*, and *Cœnosia*. (Mr. Brunetti informs us that *Anthomyia peshawarensis*, Big., described in I. M. Notes as parasitic on locusts, is really *Chortophila cilicrura* Rond.)

CALYPTRATES.

Calyptrate Muscoids are those which possess well-developed squamæ, have the male eyes closer together than the female. and the 1st posterior cell completely closed or distinctly narrowed at its outer end (except in some blood-sucking species). We include in this division four families, the *Tachinidæ*, *Sarcophagidæ*, *Muscidæ* and *Œstridæ*. The *Sarcophagidæ* and *Œstridæ* are comparatively small families, but the *Tachinidæ* and *Muscidæ* have each a very large number of closely related species. The fact that so many of the species are so much alike makes their classification (especially in the case of the *Tachinidæ*) extremely difficult. and even the numerous genera are often so close together and separated by such very slight characters that the student will not be able to distinguish them unless he makes a special study of the families. Their classification is still in an unsatisfactory condition. although much work has been done on the European and American species. In particular. the Indian *Tachinidæ*. which are evidently extremely numerous. have hardly been touched, and the work that has been done in the past will need a large amount of revision to bring it into line with modern classification. For these reasons. and since it must be some years before the Indian Calyptrates can be really well known. I can treat of them only in a superficial manner. but the student should not think that because the treatment is superficial the families are therefore unimportant. Leaving the *Œstridæ* for the present, we will begin with the three families *Tachinidæ, Sarcophagidæ* and *Muscidæ*. Taken as a whole they are moderately large, more or less bristly, grey blackish or blue flies; many have the general appearance of house-flies or blue-bottles; they are distinguished as follows:—

Arista bare. Upper side of abdomen generally bristly on the basal segments. Larvæ parasitic	*Tachinidæ.*
Arista bare at the end, but with hairs on the basal half. Basal segments of abdomen generally without strong bristles. Larvæ parasitic or scavengers	*Sarcophagidæ.*
Arista, on at least one side, hairy or plumose along its whole length. Abdomen generally smooth, not bristly on the basal part. Larvæ mostly scavengers	*Muscidæ.*
(If like this, and with strong, horny, more or less elongated proboscis, *but with 1st posterior cell open as in Anthomyiids*)	"Biting" *Muscidæ* (See pp. 645, 659).

MUSCIDÆ.

Rather small compactly-built flies. The abdomen of four visible segments, not bristly on its basal part, and not swollen at the tip in the males as in Sarcophagidæ. The antennal arista plumose to the tip at least on one side. 1st posterior cell closed or much narrowed except in some of the blood-sucking species where it is only slightly narrowed; eyes in males much nearer together than in females, often touching.

This family comprises those house-flies, blue-bottles and blow-flies which are familiar insects wherever man has made his home, and also, be it remarked, where he has not. Almost all the very numerous species may be said to closely resemble in colour and general appearance one of these two types, the house-fly or the blue-bottle. The life-history is short, a fair average period for the commoner species being 10 to 15 days, but this is subject to considerable variation with food and temperature. The number of eggs varies very much in the different species. *Musca corvina* lays only twenty or thirty, *M. domestica* a hundred

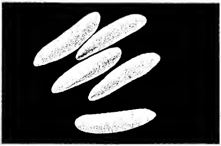

Fig. 422—Eggs of House-fly × about 20.
(*After Newstead.*)

to a hundred and fifty, while some of the blue-bottles (*Lucilia* and *Calliphora*, etc.), may lay five or six hundred. The eggs rarely take longer than a day to hatch, and the young are sometimes deposited as larvæ, as in many *Sarcophagidæ* and some *Tachinidæ*. The eggs are as a rule white (those of *Hæmatobia* are black) and mostly resemble those of the house-fly (fig. 418) though some have a process from one end running longitudinally down one side of the egg. The great majority of the larvæ are scavengers and live in dung or in decaying animal or vegetable matter. They are typical "maggots," the body thick behind and tapering in front to a rudimentary head provided with a pair of dark-coloured chitinous mouth-hooks. The maggots of different species are often extremely alike, and practically the only way of distinguishing them is by slight variations in the structure of the spiracles. The pupæ are cylindrical, rounded at both ends, and chestnut brown in colour, and the larvæ nearly always pupate in the earth, generally one or two inches below the surface, sometimes travelling some little distance before they bury themselves. A few are found in wounds, and the larvæ of *Pycnosoma* (Pl. LXIX, fig. 2) appear not infrequently to cause Myiasis by their presence in the nostrils of human beings and camels. With these exceptions, however, the larvæ are distinctly beneficial as scavengers. The fly figured on Pl. LXIX, fig. 4 (*Ochromyia*), is of some interest as being closely related to an African Muscoid (*Auchmeromyia*) whose larva has the unique habit of sucking human blood. The larva of *Ochromyia* has not yet been discovered, but the adult fly is recorded as having been observed to prey upon swarming termites, catching them on the wing, while we have more than once seen them commit highway robbery on ants : three or four Ochromyias will sit near a nest watching an ant-path along which the ants are passing to and fro : when one passes carrying a tender nymphal ant or pupa in its jaws an Ochromyia will pounce down and try to pull the nymph away, being generally but not always successful, and will then carry it off to a neighbouring twig or leaf where it can be sucked at leisure. The house-flies of India include the cosmopolitan *Musca domestica*, Linn.,

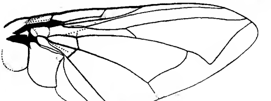

Fig. 423—WING OF OCHROMYIA, SHOWN AS A TYPE OF A MUSCID WING.

and *M. corvina*, Fab., and another species which is common may be *M. determinata*, Wlk. They breed in decaying refuse of all sorts, especially in dung, and it will often be found that plagues of flies are due to the near presence of stables and cease as soon as measures are taken either to remove the stable refuse daily, or to protect it from flies with a layer of lime, by copiously sprinkling it every day with crude-oil emulsion, or a solution of Cyllin (Shipley), or by keeping it thoroughly soaked with water, or in fly-proof bins or pits. The heaps of decaying vegetable stuff near the bungalow, so often seen on indigo-planters' estates, are one of the main causes of the plagues of flies from which they periodically suffer, and here *Stomoxys* often breeds freely.

The student should consult Hewitt (Q. J. M. S. 1907 and 1908 "On the structure development and bionomics of the House-fly") where he will find further references to literature.

To avoid having the house and kitchen infested with flies is a matter of importance to health, since the insects carry on their feet and other parts of the body traces of the filthy matter on which they are accustomed to sit and suck, and are liable to infect our food and milk with the germs of stomach-diseases derived from this filth. Kitchens should be kept very clean, and no refuse of any kind allowed to lie about in the kitchen or near it. All food when not in use should be kept in close-shutting wire meat-safes, or at least so covered that no flies can get at it. Particular care should be taken in the safe disposal of night-soil.

The blue-bottles of India belong chiefly to the genera *Lucilia*, *Pycnosoma*, *Thelychæta*, and *Pyrellia*, while the common English *Calliphora erythrocephala*, Mg., occurs in the hills, but not in the plains. They are much less common in houses than are the house-flies of the genus *Musca*, and a considerable number of their larvæ live only in decaying flesh or other animal matter. It is perhaps owing to the quickly-perishable nature of this food that so many of the blue-bottles lay such a large number of eggs as compared with the house-flies. The fly shown on Pl. LXIX, fig. 5, as *Idia*, illustrates a distinct type of Muscid with a prominent face and proboscis. Species of *Idia* or *Rhynchomyia* are not uncommon on flowers and may be recognised easily by their peculiar dull metallic look, quite unlike that of most *Muscidæ*. The larvæ are said to be parasitic on other insects.

There remain the important group of blood-sucking *Muscidæ*. There is no easily recognisable character which will separate them from many other flies of similar general appearances: the best character is that they suck blood. The importance of obtaining accurate knowledge of the distribution and habits of these blood-sucking *Muscidæ* is, from the point of view of the stock-owner and breeder, very considerable, since it is extremely probable that these flies, together with some of the *Tabanidæ*, are able to carry from one animal to another, the parasite which causes the very serious disease known as "Surra" (Trypanosomiasis). This parasite is extremely minute, quite invisible unless looked at through a microscope, and when seen alive in the blood of the diseased animal it has rather the appearance of a wriggling eel with a somewhat flattened body. An almost exactly similar parasite is the cause of the generally fatal human disease in Africa called "Sleeping-sickness," and this latter parasite is carried from man to man in the proboscis of *Glossina*, an African blood-sucking Muscid. In both sleeping-sickness and Surra the parasite is conveyed much in the same way as the malaria parasite is conveyed by mosquitos, but with this difference, that the parasites ("trypanosomes") of sleeping-sickness and surra do not, it has been thought, multiply in the body of the fly, but are simply carried in the insect's proboscis. Recent work on sleeping sickness tends to prove, however, that a developmental cycle is undergone by the parasites in the tsetse fly (*Glossina*).

All the Indian blood-sucking *Muscidæ* are similar to house-flies in size and general appearance, except that *Lyperosia* is a good deal smaller. The commonest species is *Stomoxys calcitrans*, Linn. (Pl. LXIX. fig. 3). *S. indica* is not uncommon, and two or three other species of *Stomoxys* may also occur. The two common species of Lyperosia (*L. exigua*, de Meij., and a smaller one *L. minuta*, Bezzi) are abundant in certain localities but are rarely seen in others. *Hæmatobia* (*H. irritans* and one or two other species) is less common. There remain two or three species belonging to new genera recently described,* which are interesting as including one fly which is intermediate between the above-mentioned species and the ordinary house-flies, especially in wing-venation and the structure of the proboscis, which are the points in which the biting *Muscidæ* usually differ from the non-biting. For convenience of reference we have included a plate of rough drawings of the chief types of Indian blood-sucking insects, and division C on the plate shows the head and wing of *Lyperosia*, *Stomoxys*, *Hæmatobia*. *Philæmatomyia*, and *Musca* the house-fly. Examination of the plate will show that the first posterior cell is nearly closed in *Musca* and *Philæmatomyia* but quite open in the others, while the proboscis, long in *Lyperosia*, *Stomoxys*, and *Hæmatobia*, is in *Philæmatomyia* more nearly equal in length to that of the house-fly, though it is very stout and strongly chitinized. It is noteworthy that in biting this chitinized portion is not as in *Stomoxys* inserted into the wound, but remains outside like the labium of *Culicidæ*, the actual puncture being made by an inner eversible portion which is armed at the end with a ring of stout hooks. This eversible portion is roughly indicated in the illustration.

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* *Philæmatomyia insignis*, Austen Ann. Mag. Nat. Hist. Mar. 1909, the only species known at present. Fairly common and widely distributed. *Bdellolarynx sanguinolentus* Austen l. c. the only species known. Not common.

All these flies except *Stomoxys* breed in dung, and details of some of the life-histories may be found in Bulletin No. 7 of the Agricultural Department. Further information will be found in a future publication. The genera are separated as follows; the new ones alluded to above may be recognised by being found biting cattle and by the stout dark brown and polished proboscis.

1st posterior cell open—	
(*a*) Proboscis long, much longer than the palpi, which are short and slender	*Stomoxys.*
(*b*) Palpi broad at the tip, much longer than in *Stomoxys*, but not as long as the proboscis ..	*Hæmatobia* and one new related genus, *Bdellolarynx.*
(*c*) Palpi as long as the proboscis for which they form a sheath. The flies a good deal smaller than *Stomoxys* or *Hæmatobia*	*Lyperosia.*
1st posterior cell much narrowed or closed, proboscis short and stout	*Philæmatomyia.*

Reference to literature on the subject of the relation of muscid flies to disease cannot be given here, since the papers are so numerous and scattered. An excellent summary of the whole subject up to 1899 is given by Nuttall, Johns Hopkins Hospital Reports, Vol. VIII "The rôle of insects, etc., in the spread of diseases" L. O. Howard's "Study of the fauna of Human excrement" Proc. Wash. Acad. Sci. 1900 gives much information as to possible food-infecting American species; while for the rest the writings of Austen, Bezzi, Bruce, Hewitt, Newstead, Nuttall, Shipley and others in various scientific, medical and veterinary journals should be consulted. The Reports of the Sleeping-sickness Commission and Austen's "Monograph of the Tse-tse Flies" give a large mass of information relating to the African *Glossina*, while Neumann's "**Animal Parasites**" contains an excellent general account of the Dipterous and other pests of cattle and horses.

SARCOPHAGIDÆ.

Rather large usually grey and black flies. Antennal arista bare at the end, plumose on the basal half. Male eyes not markedly nearer than in the female. Squamæ generally large. Abdomen of four visible segments, not noticeably bristly on the upper basal portion. 1st posterior cell much narrowed or closed. Male genital organs often noticeable as a rounded projection under the tail. Tarsi rather large.

These flies are common all over India, and as a rule easily to be recognised by their red eyes and by their having the thorax grey striped longitudinally with black, and the abdomen with a checquered "shot" pattern of dark and light grey. They are often known as "Flesh-flies" getting the name from the fact that they will readily lay their eggs in meat, especially if it has begun to go bad. The larvæ are maggots in which the segments are fairly distinct, each being marked by a band of minute spiny bristles. The posterior stigmata lie at the bottom of a cup-shaped depression at the hind end of the body (fig. 424). The eggs are white, sometimes slightly curved, but in at least several species larvæ are usually deposited instead of eggs, the latter having hatched within the body of the parent fly. This habit obviously ensures that the larva shall at once have access to the food-supply in the midst of which it is placed, and it has been observed to occur in species of *Sarcophagidæ* which have been identified as causing Myiasis in man, the larvæ being deposited in open wounds, ulcers, or in the nostrils, where they feed and burrow into the tissues, often causing much pain and frequently death from blood-poisoning. If wounds are dressed with carbolic preparations, tar, or other strong-smelling substances the flies will not deposit eggs or larvæ therein. If larvæ are found in a wound they should be

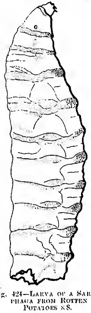
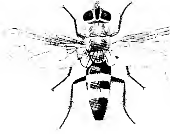


Fig. 424—LARVA OF A SARCOPHAGA FROM ROTTEN POTATOES ×8.

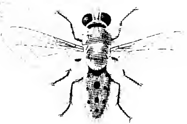
PLATE LXVIII.—TACHINIDÆ.

Fig. 1. *Demoticus strigipennis.*
„ 1*a*. } Head.
„ 1*b*. }
„ 2. *Miltogramma* 12-*punctata.*
„ 2*a*. } Head.
„ 2*b*. }
„ 3. *Calodexia lasiocampæ.*
„ 3*a*. } Head.
„ 3*b*. }
„ 4. *Masicera subnigra.*
„ 4*a*. } Head.
„ 4*b*. }

The figures on this plate are accurately copied from water-colour drawings made by the late F. M. Van der Wulp.



I



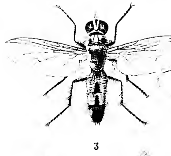
2

Ia.

Ib.

2a.

2b



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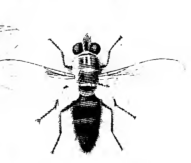


4

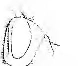
3a.

3b.

4a

4

4b



carefully and completely removed, and the place very thoroughly washed out with carbolic acid or other antiseptic solution. The removal of the larvæ is made much easier by holding over the wound for a short time a rag wetted with chloroform or spirits of turpentine. Simple application of carbolic acid, or even corrosive sublimate solution, will not necessarily kill the maggots, as like most Muscoid larvæ they are extremely tenacious of life. The puparium is of the usual rounded cylinder type, with well-marked posterior stigmata. The length of the life-history of the Indian species appears to vary a good deal, being quite short (two to three weeks) in the flesh-eaters and longer in the parasitic forms; the flies can frequently be found breeding in the decaying bodies of animals, sometimes in great numbers, together with various species of *Muscidæ*, the "blue-bottles" and "blow-flies."

Although the flesh-flies are so abundant, the known Indian species nearly all belong to one genus *Sarcophaga*. Van der Wulp lists *Cynomyia quadrivittata*, Macq., from "E. India," and the British Museum has a representative of the genus *Agria* from Karachi. About eight species of *Sarcophaga* appear to be known from this country, and one of the commonest, *S. lineatocollis*, Macq., is shown on Pl. LXIX, fig. 1.

TACHINIDÆ.

Body usually very bristly. Arista bare along its whole length. Proboscis occasionally long. Larvæ parasitic, adults flower-flies.

The *Tachinidæ* of all insects are among the most beneficial to the agriculturist. This is owing to their being apparently all parasites on other insects, and there is no doubt that were they absent the damage caused by insect pests, especially Lepidoptera, would be considerably larger than it is. Though Hymenoptera, and occasionally Orthoptera and other orders, are attacked, the flies as a rule lay their eggs on the bodies of caterpillars, generally near the head end. When the eggs hatch the young larvæ bore through the skin into the caterpillar's body and consume its internal organs; they are thick, fat and rounded, with small anterior and large posterior spiracles, the segments of the body

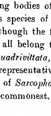


Fig. 425.—LARVA OF A PARASITIC TACHINID ×8.

rather indistinct. Sometimes the caterpillar dies under this treatment before it can pupate, but very often the pupal stage is reached. The Tachinid larva when full fed generally leaves the body of its host (which then always dies) and pupates in some sheltered spot, usually just below the surface of the ground. Most of the *Sarcophagidæ* and *Muscidæ* also habitually pupate one or two inches deep in the earth near the place where their larval stages were passed through. Unlike most of the parasitic *Hymenoptera*, *Tachinidæ* do not seem necessarily to confine themselves to particular hosts, and one species of Tachinid may lay eggs on caterpillars of several different species indiscriminately. They also not infrequently make the mistake of laying eggs on a caterpillar which is already attacked, and in such cases many of the larvæ must necessarily be starved, since the caterpillar can provide food only for a limited number: similarly in the nests of Hymenoptera which store spiders, too many Tachinid larvæ are sometimes found, the supply of spiders, being insufficient for all, so that some die or are eaten by their fellows. Again, eggs are sometimes laid just before a moult, and if the caterpillar can cast its skin before the Tachinid larvæ hatch it will of course escape and the larvæ will die. Among the parasitic Hymenoptera such mistakes and irregularities as these are very rare, the life of the parasite being generally arranged so as exactly to correspond to, and as it were fit into the weak places in, the life-history and habits of its host. As has been said already, it is possible that the Calyptrates are a group of comparatively recent development, and it may be that their imperfect adaptation to a parasitic mode of life is due to their having taken up this mode of life comparatively lately, their habits and instincts having not yet reached that precise adjustment which has been attained by many parasitic Hymenoptera.

A recent very interesting paper by Townsend (U. S. Agric. Dept. "Record of rearing *Tachinidæ*") contains much new information on the varieties of oviposition and "larviposition" among Tachinids, and reveals considerable diversity among different species. He has made the curious discovery that certain American Tachinids do not lay their eggs on the caterpillars, but on the leaves, so that they are eaten by the caterpillar and hatch in its stomach, a method very similar in essentials to that followed by *Gastrophilus* among *Œstridæ*.

As already mentioned the classification of Tachinids is still in the making. The Indian species have not yet been seriously studied, and except for van der Wulp's catalogue, which gives references to previous work, there is no special literature to which reference can be made. The student of the Calyptrates will find a standard work in Brauer and Bergenstamm's "Die Zweiflügler des kaiserlichen Museums in Wien" Parts I—IV, but he may experience some difficulty in using it. A good deal of useful information will be found in Townsend's "Taxonomy of the Muscoidean Flies" (Smithsonian miscellaneous collections. Washington 1908). As to the number of species of India, it will certainly prove to be very large. Van der Wulp records between forty and fifty, but a large proportion of these will be placed in different genera when the revision of the family is undertaken. The best known are two parasites of the silk-worm, *Crossocosmia sericariæ*, Rond., and *Tricolyga bombycis*, Bech., of which an account will be found in I. M. Notes. *Miltogramma duodecimpunctata*, V.d.W., is there recorded as being a parasite of the locust *Acridium peregrinum*, Oliv., but it seems to be so rarely found in this connection as to be quite inefficient as a check. Pl. LXVIII gives a good idea of the general appearance of typical members of the family.

ŒSTRIDÆ.

Rather large flies, sometimes furry and having a slight resemblance to bees. The mouth-parts small or rudimentary: antennæ short and inconspicuous. Wings sometimes clouded. venation generally similar to Muscidæ. Ovipositor sometimes large. Squamæ usually large.

This family is of one of considerable importance. for its members are all parasites in the larval stage on warm-blooded animals. and include the "Bot-flies" whose larvæ live generally in the stomach. and the "Warble flies" whose larvæ are usually found under the skin. where they cause swellings known as "Warbles." Miss Ormerod (Ind. Mus. Notes) estimated that no less than 48% of the hides exported from India were damaged owing to the holes caused by these larvæ. The eggs of nearly all Œstrids are probably laid on the skin of the animals attacked. which may be horses. cattle of all kinds. donkeys. sheep. camel and a variety of wild animals. The eggs themselves are usually provided with a curious clasp at one end which anchors them to the hair on which they are laid: those shown in fig. 426 were taken from the fore-legs of a horse, the position where they are usually found. The animal is supposed to lick off the eggs when hatched, owing to the irritation caused by the young larvæ, which are thus carried into the throat and stomach. They may remain in the stomach until ready to pupate, when they are passed out with the fæces (*Gastrophilus*), or may in the

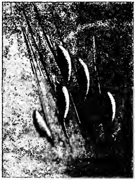


Fig. 426—Eggs of Gastrophilus equi attached to Horse's Hairs. (× about 10.)

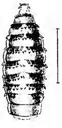


Fig. 427—Gastrophilus equi Larva. (*After Bau.*)

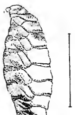


Fig. 428—Œstrus ovis Larva (*After Bau.*)

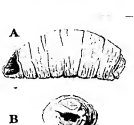


Fig. 429—A. Empty Puparium of Œstrus ovis. B. Posterior end of same. (× 3.)

course of months gradually work their way outwards to the back, where they perforate the skin, moult and become spiny, causing a sore swelling in which they live until ready to pupate, when they work their way out by means of their spines and fall to the ground, the fly emerging from the pupa in three or four weeks (*Hypoderma*). The best-known species in India is *Œstrus ovis* (Pl. LXIX, fig. 6), which lives in the noses of sheep, and is sneezed out when ready for pupation. Fig. 425 shows the empty pupa-case. Mr. Middleton has sent us larvæ of *Cephalomyia maculata*, Wied., which he found living in a similar way in the nostrils of camels (fig. 430). The life-histories of the family, as a whole, are very incompletely known owing to the difficulty of observing the stages in the living animal, and the habits of the flies themselves are hardly known at all. The family is by no means uniformly disturbed over India; we have no knowledge of the condition of things in Southern India, but, excluding Madras and the west coast, it seems probable that *Hypoderma*, the common European genus, is confined to Western India, from the Punjab southwards probably as far as Gujerat. Mr. D. Quinlan (Superintendent, C. V. D., Bengal) informs us that he has rarely or never seen warbles in Bengal cattle except in the hills, and this agrees with our own experience. *Œstrus* is, however, not uncommon in Bengal, and *Gastrophilus* also occurs in certain districts. It is a large yellow rather bee-like fly with clouded wings and a large and complex ovipositor. The preventives usually tried are strong-smelling washes, tar or grease, applied to the skin of the cattle with the object of deterring the flies from laying their eggs, or greasy and other dressings applied to the swelling on the back. Neither method appears to be entirely effective (Carpenter and Steen, J., Agric. Dept., Ireland, Vol. VIII) and lancing or squeezing out the larvæ as soon as they are nearly mature seems the only thing to do in the present absence of knowledge of the habits of the flies: the wound should then be dressed with crude oil emulsion to deter Muscids or Sarcophagids from depositing their eggs or maggots on the raw surface. A very good summary of what is known of the habits is given by Imms. (J. Econ. Biology, Vol. 1). A general account of the family is given by Dr. Bau (Gen. Insectorum, *Œstridæ*) who lists four species from India. These are *Cobboldia elephantis*, Cobb., in the stomach of the Indian elephant; *Gastrophilus equi* Fab., in the stomach of the horse (*G. pecorum* Fab., from Deesa is in the British museum collection):

Œstrus Ovis, Linn., in the nasal cavities of the sheep; *Hypoderma bovis*, De Geer, under the skin of cattle. *Cephalomyia maculata*, Wied., also occurs as mentioned above, and *Microcephalus przewalskyi*, Ptch., has been taken in Sikkim (Brit. Mus. Coll.).

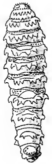


Fig. 430—Larva of Cephalomyia maculata ×2.
(*After Bau.*)

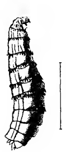


Fig. 431—Cobboldia elephantis. Larva.
(*After Bau.*)

PUPIPARA.

Hippoboscidæ.

Flattened leathery-looking parasitic flies, sometimes wingless. Proboscis short protected by the palpi; head small, without distinctly seen neck. Legs strong with powerful claws, antennæ very small & inconspicuous.

These "kuku-macchi" "cattle-flies," "skaters." "dog-flies" must be familiar to every one in India, since they are common in many districts on cattle and dogs. To dogs, especially those of European breeds, they seem to cause much discomfort, and even the knowledge that a Hippoboscid is flying in its vicinity will often render a dog obviously restless and uneasy in its mind. On cattle they are often to be seen in crowds, but the native breeds do not seem as much affected by their attacks as might be expected from the number of the flies (very often twenty or more on one animal). The life-history of these flies is of a curious and interesting type. We have seen that certain Calyptrate Muscoids (*Sarcophagidæ* and *Tachinidæ*) often retain the eggs within the body until after they have developed into larvæ, and that they are thus "viviparous," *i.e.*, produce their young alive. These larvæ at once begin to feed, and when full-grown they pupate. The *Hippoboscidæ* and probably all other Pupipara carry the process still further, their larva remaining inside the present fly's body until ready to pupate, when they are deposited. The puparia, found lying generally on hard dry surfaces (floors, stone window-sills, shelves, etc.), are dark mahogany brown in colour, round and polished, with a black cap at one end, and look very much like round smooth seeds about half as big as a pea. When first laid they are nearly white (fig. 432). It is thus obvious that in *Hippoboscidæ* the usual conditions found among Diptera regarding the taking of food are reversed. As a rule it is the larva which does most of the feeding required for the insect's development, and this is true even in families such as *Asilidæ*, in which the adults are predaceous, and in the blood-sucking *Culicidæ*, *Psychodidæ*, *Simuliidæ*, and *Tabanidæ*. The same rule applies to the Indian species of blood-sucking *Muscidæ*, but the African Tsetse-fly retains the larvæ until ready to pupate, in the same way as *Hippoboscidæ*, and it is evident that this abbreviated life-history is due to the fact that the adult fly is able by sucking blood to supply enough nutriment to carry on the life of the larva as well as its own. In accordance with this, since the fly can only absorb a limited quantity of blood, we find that reproduction in *Hippoboscidæ* (and in the Tsetse-fly) is slow, only one larva being produced at a time, but the slowness of the process is to a great extent compensated by the protection of the young from all the dangers of larval life; that this protection is effective we see from the abundance of the flies. The shortening of

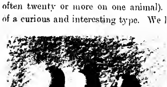


Fig. 432—PUPARIA OF HIPPOBOSCA.
The one on the left is new laid, that in the middle is six hours old, and the one on the right a week old, and dark brown in colour. ×4.

the life-history in the Sarcophagids and Tachinids has probably arisen for a rather different reason. Not only is it an advantage from the fact that the shorter the helpless period in the egg the less chance there is of destruction, but a short egg-period is of the utmost importance to such larvæ as live in dead flesh and similar substances, owing to the rapidity with which the food on which they depend may entirely decompose or get completely dried up by the sun. Sarcophagids will often lay at least forty or fifty young larvæ on one piece of meat, the main object evidently being to make certain that at any rate some of these shall get food at once and be able to make the best of their opportunity before the supply dries up or becomes otherwise unavailable. A number of articles on *Hippoboscidæ* by Dr. Speiser in the last year or two of the "Zeitschrift für wissen-schaftliche Insektenbiologie" give a large amount of information about the family. He recognises five sub-families, of which four occurring in India are distinguished as follows :—the commonest Indian species are *Hippobosca maculata*, Lch., and its variety *sivæ*, Big., on cattle, and *H. capensis*, Olf., on dogs (*Hippoboscinæ*) with *Lynchia exornata*, Sp., on pigeons (*Olfersiinæ*).

Ocelli, and anal cell absent. Wings well developed.
(1) Pronotum invisible from above .. .. *Olfersiinæ*.
(2) Pronotum visible from above as a coloured projecting ring .. .. .. *Hippoboscinæ*.
Ocelli present or absent. Wings either very weak or practically absent .. .. .. *Lipopteninæ*.
Ocelli present or absent. The wings developed or reduced, the former usually with an anal cell. Those with an anal cell possess ocelli; others have no distinct venation .. .. .. *Ornithomyiinæ*.

NYCTERIBIIDÆ.

Wingless flies, with very small head bent back over the thorax when at rest. Legs long. General appearance spider-like.

The *Nycteribiidæ* are entirely parasitic, and are most remarkably modified in structure. They are found on bats, and cling to the skin or fur of their hosts. Their position is however the reverse of the usual one, since when thus clinging they have the back next to the body of the host and their ventral surface outward. To fit this attitude the head is bent back so much that it appears to spring from the dorsal part of the thorax, while the legs with their big claws also have their position somewhat modified in accordance with this curious habit. Pl. LXIX. fig. 8, represents *Cyclopodia hopei*, Wstw. (= *Sykesi*), taken from a " flying-fox " at Pusa. Little seems to be definitely known about the life-histories of these very remarkable insects, but what is known indicates that the development may be of a curious and exceptional nature. The species recorded from India are *Raymondia pagodarum*, Sp., *Cyclopodia hopei*, Wstw., and *Polyctenes lyræ*, Waterh.

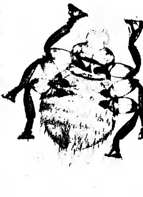


Fig. 433—Braula coeca, the Bee-louse.
Highly Magnified.
(*After Cowan.*)

Braulidæ.

Minute wingless parasites of bees.

The figures show a "bee-louse" (*Braula*). Little is known about them further than that they are found clinging to the thorax of bees. They are not recorded from India.

SIPHONAPTERA.—(*Fleas*).

Small parasitic blood-sucking jumping insects with body flattened from side to side ; the eyes simple, not compound ; wings rudimentary, the skin horny. Mouth-parts well-developed for piercing and sucking. Antennæ concealed in grooves.

The Fleas are usually looked on as being Diptera, although the wings are practically absent and the whole form and structure of the insects have been profoundly modified, presumably in accordance with their parasitic habits. Though the idea that fleas are flies at first sight appears to be a little far-fetched, the modification which they have undergone is after all not much greater than in the parasitic *Cyclopodia* figured on Pl. LXIX or than in certain parasitic *Phoridæ* such as *Termitoxenia* (fig. 400). Their active habits and the voracity with which they suck blood are known to most people. and these characteristics, together with the long strong hind legs and the curious shape of the body, which is excellently fitted for gliding easily among hair, fur or feathers, make them unmistakeable. The sexes are a good deal alike. but the female is larger, has a less abruptly tip-tilted tail, and has not the coiled internal horny attachments of the genital organs which are present in the male. and which are shown in all the figures on Pl. LXXI. The eggs are laid on floors, dusty carpets, or dry earth, and hatch into slender larvæ of a more or less dipterous type, with rather strong hairs and a biting mouth with which they consume what nutritive matter they can find among the dirt in which they live. When full grown they spin a cocoon which is usually coated with dust and dirt, and there transform to a pupa. The life-history may be easily observed by keeping females in glass bottles with a little loose dry dust and dirt, such as floor-sweepings, in which the larvæ may live. Too much moisture is very distasteful to the young and adult stages, and they probably flourish best under certain very definite conditions of temperature and humidity. as is the case with many other insects. The larvæ are killed almost immediately when wetted.

The rat-flea (*Pulex cheopis*, Roth.) is an insect whose study has become of the first importance since the work of Lamb, Liston, and others has shown that its bite constitutes one of the chief ways, even if not the only one, whereby plague is spread. The rat-flea is essentially a parasite of the rat, but it does not confine its attacks to these animals. and it will bite man, especially (but not only) when there are no rats on which it can feed. It is well known that before plague attacks the men of a village, the rats of the place usually die of the disease. When the rats die, it is presumed that the rat-fleas leave their bodies and are then particularly liable to bite men, and

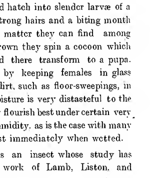


Fig. 434—PUPA AND LARVA OF FLEA much enlarged. The figure is a bad one.

PLATE LXX.—BLOOD-SUCKING INSECTS.

Division A contains those blood-sucking Nemocera whose antennæ are long and easily seen, *Phlebotomus* (Psychodidæ), *Ceratopogon* (Chironomidæ) and Mosquitos (Culicidæ), with rough sketches of the larva and pupa of each. *Phlebotomus* and *Ceratopogon* are about twice natural size, and are drawn in their usual resting attitude.

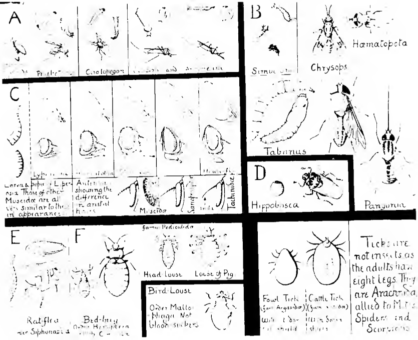
Division B contains *Simulium*, and the four main genera of Tabanidæ, the latter showing the usual resting attitudes, and the larva and pupa of the commonest genus, *Tabanus*.

Division C contains sketches of the wing and head of the main genera of blood-sucking Muscidæ, showing the relative lengths of proboscis and palpi and the hairing of the arista, with the amount of closure of the 1st Posterior cell. (The unnamed head and wing are those of *Philæmatomyia*.)

Division D shows the puparium and imago of *Hippobosca*.

Division E Flea.

Division F. Hemiptera—young and adult bug (Cimicidæ) and two lice, *Pediculus capitis* and *Hæmatopinus urius* (Pediculidæ).


A
Culolegon
and
B
Chrysops
Hæmatopota
C
Tabanus
Larva & pupa of L per-
osia Those of other
Muscidæ are all
very similar to them
in appearance
Antennæ
showing the
difference
in aristal
hairs
Muscidæ
Tachinidæ
D
Hippobosca
Pangonia
E
F
famil Pediculidæ
Head Louse
Louse of Pig
Bird Louse
Order Mallo-
phaga Not
blood suckers
Rat flea
Order Siphonaptera
Bed-bug
Order Hemiptera
Fowl Tick
(fam Argasidæ)
Cattle Tick
Ticks are
not insects as
the adults have
eight legs They
are Arachnida
allied to Mites
Spiders and
Scorpions

thus infect them with the plague bacillus which the fleas have previously sucked up with the blood of the rats on which they last fed. The literature on the subject of fleas and plague is considerable, and the student is referred to the Reports on Plague Investigations in India issued by the Advisory Committee, and published in the "Journal of Hygiene," Vols. VI and VII. The classification of the group is somewhat difficult, as it is based largely on minute characters. C. F. Baker's "North American Siphonaptera" and Jordan and Rothschild's "Revision of the Non-Comb-eyed Siphonaptera" (Parasitology, Vol. I) may be consulted. The "Comb" refers to a row of stout spines round the lower part of the head which is present in certain species, as in *P. felis*, the cat and dog flea. This species is shown on Pl. LXXI, copied from the Plague Investigation Report, on which are also shown *Ctenopsylla musculi*, a mouse and rat-flea; *Pulex irritans*, the human flea; *Ceratopsyllus fasciatus*, the European rat-flea; and *Sarcopsylla gallinacea*, the fowl-flea.

INDIAN BLOOD-SUCKING INSECTS. ✓

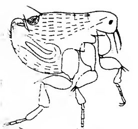
As we all know, India is a country which has its full share of those vermin which spend the whole or part of their lives on the bodies of men and other warm-blooded animals, and also of those equally annoying insects which alight upon the body of their victim only when intent on gorging themselves with his blood. Of common vermin, the Bird-lice or Mallophaga (p. 110), are not blood-suckers, though they live as parasites on the bodies of their hosts: the blood-sucking species of insects at present known in India may be said to belong exclusively to two Orders, Diptera and Rhynchota. To the first of these may be assigned the Fleas, which probably represent a much-specialised offshoot from the old Dipterous stock, though they are generally given the rank of a separate Order or Sub-order (Siphonaptera). They represent that section of the Diptera which pass a considerable portion of their adult life on the host, though the egg, larval, and pupal stages are usually gone through elsewhere, in dusty and dirty places. Their importance in connexion with plague is well known. Except for the fleas, few blood-sucking Diptera spend much time on the body of the host, but the lives of adult *Nycteribiidæ* and *Hippoboscidæ* afford an interesting series of examples of variation in this respect. Some of them, for instance the one figured on Pl. LXIX, fig. 8, appear to pass at least most of their lives on the host, and most of these species are wingless or feeble-winged: at the other end of the scale are the common cattle-flies (*Hippobosca*) which have strong wings, are quick fliers, and are always ready to strike camp and leave the host on whom they have settled, though remaining if comfortable and undisturbed. These two families exhibit the mode of reproduction characteristic of the group (Pupipara) to which they belong (p. 655), and although little is known of their habits and life-histories it is probable that, as is the case with all other blood-sucking Diptera, the adult stage is the only one which has any direct connexion with the host, while as indicated above the closeness of this connexion varies considerably within the limits of the two families, and probably has influenced the reproductive processes to a considerable extent. After those groups, Siphonaptera and Pupipara, which pass a considerable portion of their adult lives on the host, we come to those Diptera which pay as a rule only flying visits to their victim, and take their leave after a short but hearty meal of blood. These belong to six families, and of these families five are particularly well represented in this country, the sixth (*Chironomidæ*) being comparatively unimportant. The family which by relationship and habits approaches most nearly to the Pupipara is the *Muscidæ*: as with the *Hippoboscidæ*, which practically never bite man, the attacks of the Indian species of *Muscidæ* are as a general rule confined to cattle, but this is by no means always the case, as in some districts and climatic conditions they (especially *Stomoxys*) will bite men viciously. *Stomoxys* is the commonest of the Indian genera, the others being *Lyperosia*, *Hæmatobia*, *Philæmatomyia* and *Bdellolarynx*. All the four latter are found as larvæ in dung, but *Stomoxys* breeds by preference in fermenting vegetable matter, especially in heaps of grass and fodder, and in the piles of "seet" near indigo-vats, the flies being often so abundant at the period of mahai as to be a serious nuisance. These *Muscidæ* often remain for a considerable time on the cattle, but this is probably in part because they are so frequently interrupted in their feeding by the movements of the victim, and they will persevere in the attack until satisfied with blood. All the blood-sucking *Muscidæ* have a strong superficial likeness to many other *Muscidæ* which do not suck blood, such as the house-fly, and to others which are often found sucking blood from wounds but which cannot pierce the skin for themselves: this the five blood-sucking genera are of course able to do, but whereas in *Stomoxys*, *Lyperosia*, and *Hæmatobia* we find a much modified and developed piercing proboscis, the mouth-parts (as also the venation) in one of the two new genera (*Philæmatomyia*) differ much less conspicuously from those of the non-blood-sucking *Muscidæ*, and the genus represents a connecting link between the two groups. Although not blood-suckers, the flies whose larvæ live in wounds or sores may be here noted as also belonging at all events for the most part to the family *Muscidæ*: the attacks of these maggots produce results often of a serious and revolting nature, and are technically known under the term "Myiasis." They attack both men and animals.

To the family *Tabanidæ* (Pl. LXII) belong a large number of species of the well-known Indian Horse-flies, Dans-flies, gad-flies, or "Clegs." The *Siphonaptera*, *Pupipara*, and *Muscidæ* comprise only insects whose

PLATE LXXI.—SIPHONAPTERA FLEAS.

a. *Pulex cheopis.* ♂
b. *Pulex felis* ♂
c. *Ctenopsylla musculi.* ♂
d. *Pulex irritans* ♂
e. *Ceratophyllus fasciatus.* ♂
f. *Sarcopsylla gallinacea.* ♂

This plate is copied from *The Journal of Hygiene*, Vol. VII, No. 3 (Report on Plague Investigations in India).



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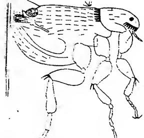

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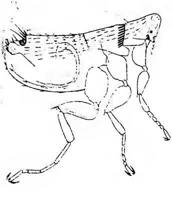

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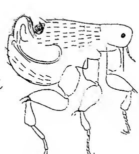

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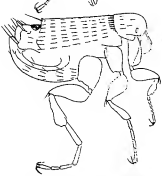

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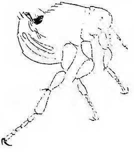

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immature stages are purely terrestrial, but in practically all species belonging to the remaining families of blood-suckers we find semi-aquatic or purely aquatic larvæ: these families may be arranged roughly in the order *Tabanidæ* and *Psychodidæ* (genus *Phlebotomus*), *Chironomidæ* (genus "*Ceratopogon*"), *Simuliidæ* and *Culicidæ*.

The larvæ and pupæ of the last two families are purely aquatic: the larvæ of *Tabanidæ* and *Phlebotomus* live in mud, slime, or wet earth, and seek a comparatively dry spot in which to pupate, while the larvæ of *Ceratopogon* are of two kinds, some living under bark and in similar damp shady places, while others are purely aquatic and agree in this respect with the numerous species of non-blood-sucking *Chironomidæ*. We may make a further generalization by saying that in these families with aquatic or semi-aquatic larvæ it is only the female that sucks blood, whereas in the purely terrestrial families both sexes may do so. None of the former group spend any very appreciable portion of their lives on the victim, whereas several of the latter do.

As to the numerical ratio between blood-sucking and non-blood-sucking species, this varies in the different families to a considerable extent. Excepting a very few particular cases, we may say that at least one sex of all species of *Siphonaptera*, *Pupipara*, *Tabanidæ*, *Simuliidæ*, and *Culicidæ* suck blood, but of the total number of species of *Muscidæ*, *Psychodidæ* and *Chironomidæ* only a very small percentage have the habit: this paucity of species unfortunately does not mean that the number of individuals of these three families is any the less, for most of us have had abundant opportunities of observing the prevalence of sand-flies (*Phlebotomus*) at certain seasons of the year, although the number of species of this blood-sucking genus probably does not represent five per cent. of the total number of harmless species in the family to which it belongs. The same is true in an even greater degree of the Midges (*Ceratopogon*, family *Chironomidæ*) and of the blood-sucking *Muscidæ*, for they constitute only a very small fraction of the total number of species in their respective families.

As regards the second Order, Rhynchota, which includes blood-sucking species among its members, we find again that these form only quite a small proportion of the Order as a whole. Among the Lice (*Pediculidæ*)* are species which pass their whole lives from egg to adult on the body of the host, and whose structure has evidently undergone great modification to fit them for a purely parasitic existence. The Bugs (*Cimicidæ*), though often remaining for some considerable time on the body of the host (generally man), usually pass the greater part of their lives elsewhere, and seek their victim only when wanting blood.

The results of recent work on the relations which exist between the life of blood-sucking insects on the one hand, and on the other the life of man and of those animals which he breeds for his pleasure and profit, have shown an unexpectedly close connection between the two, and of this the practical outcome is seen in the growing body of knowledge relating to the transmission and spread of disease among men and cattle. There are two ways in which insects may carry the "germs" of disease from one place to another. They may alight upon the excrement of diseased persons or animals, or upon sores on the body or on any other infective matter, and may then convey the infection elsewhere on their contaminated bodies or in their excreta. The transmission in this case is purely mechanical and it is immaterial by what kind of insect it is effected, though owing to the nature of their habits it is the Diptera which are chiefly concerned. It is not however in this connexion that the chief importance of blood-sucking insects lies, but rather in the part they play in the propagation of diseases which are due to the presence of certain microscopic parasites in the blood. It seems that in general these parasites can infect a healthy animal only by being directly introduced into its blood, and in the absence of blood-sucking insects it is difficult to see how this could very often occur: on the other hand, if blood-sucking insects are present they afford at once a ready means whereby a blood-parasite might be sucked up from one animal and introduced into another at a subsequent bite. It is in this way that the parasites appear to be usually transmitted, but there is still uncertainty as to the details of the process in many cases: the chief difficulty lies in deciding whether the parasite is carried by the insect from one animal to another in a simply "mechanical" way, undergoing no change *en route*, or whether, as in the case of the malarial mosquitos, the parasite on entering the insect's body undergoes a more or less prolonged series of changes before it is in a fit state again to infect a healthy animal's blood. The fact that insects have been found to have parasites of their own which are extremely similar to certain forms of mammalian blood parasites renders the matter more complicated, as does also the remarkable hereditary transmission of infective power exhibited by certain Ticks. The consideration of the Arachnids is outside the field covered by this book, but the Ticks are of great importance as pests of cattle and dogs, which they infect with spirillar diseases ("Tick-fever," etc.) and with Piroplasmosis (Biliary fever), while they are also responsible for an often fatal disease of fowls and for a human relapsing fever, a remarkable feature being that in some species the infection is not transmitted by the Tick which bites a diseased animal, but by that Ticks' young ones. As regards the Rhynchota, there is a strong presumption that Bed-bugs are responsible for the spread of human disease, and it appears that they are capable of harbouring the organism which causes Kala-azar and possibly of transmitting it by their bite (Rogers and Patton). Comparatively little attention has yet been paid to the *Pediculidæ* which infest animals in India, but the human head-louse has been shown to transmit a spirillar fever among school-children (Mackie). Of those Diptera which chiefly attack cattle (*Hippobosca*, *Stomoxys*, and *Tabanidæ*) all three families are suspected of being the agents whereby Surra, a serious cattle-disease, is spread, and investigations are now being carried on in this country with a view to deciding their relative importance in this connexion. (Leese).

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* Often classed as a distinct order *Anoplura*.

While the Indian *Hippoboscidæ, Muscidæ*, and *Tabanidæ* are primarily pests of horses, dogs, and cattle, the remaining families of Diptera attack man freely, though they none of them confine their attentions entirely to human beings; the bull-flies or "buffalo-gnats" (*Simuliidæ*) are said to bite so fiercely and impartially as to render certain hill districts practically uninhabitable during part of the year, either for man or beast, and the ferocious little sand-flies of the plains are well-known as disturbers of our slumbers. No very serious study of the *Simuliidæ*, or of *Chironomidæ* or *Psychodidæ* seems to have been made from the medical or veterinary point of view, attention having been mainly directed to following up and extending the original researches of Ross and others on Mosquitos, but the possibility of sand-flies transmitting disease would seem at least worth investigation in this country. As far as the Indian species of *Culicidæ* are concerned, reference to the list will show that we have about a hundred species at present known, though it is certain that a considerable number still await discovery. Of these only a part act as disease-carriers; and, of those species known to be capable of so acting, not all have been found actually carrying disease-parasites in nature, but have been proved by experiment to be able to carry them. It is not improbable that all species of the genus *Anopheles* will be found capable of carrying the malaria-parasite. The commonest *Myzomyia* (*M. rossi*) is not a natural malaria-carrier, but *M. culicifacies, christophersi* (=*listoni*) and *Turkhudi* are. Of the genus *Nyssorhynchus, N. stephensi, fuliginosus, Indiensis*, and *Theobaldi* are carriers; perhaps also *Cellia albimana*. All these species are *Anophelinæ*. Among the *Toxorhynchinæ* and *Ædinæ* none are known to convey disease, but the *Culicidæ* include several dangerous species. Of these by far the commonest is *Culex fatigans*, the common brown household mosquito of Northern India. This insect carries the worm-like parasite (*Filaria*) which is the cause of various painful and unsightly conditions grouped together as "Filariasis" and including elephantiasis, lymphangitis, and divers varicose affections particularly common in South India. *Culex fatigans* has been suspected of complicity in the spread of some other diseases, but hitherto without definite proof. Another Culicine genus, *Stegomyia*, is abundant in India, the commonest species being *S. scutellaris*, which seems to be widely spread. A closely related species, *S. fasciata*, occurs in Bengal, in the neighbourhood of Calcutta, and this particular species is well known to be the carrier of yellow fever in the West Indies; whether *S. scutellaris* can also convey this most deadly disease is unknown.

The question of the chances that yellow fever may be introduced into India in the near future is one which merits perhaps more than a passing glance, and we venture to borrow a passage on this subject from Manson's "Tropical Diseases." "The probable reason of the non-introduction (of yellow fever) into Asia is that the trade route from the West Indies to China and India has hitherto not been a direct one, but has passed by a long circuit either to the North or to the South. When the American inter-oceanic canal has been constructed, there will be direct and rapid communication between the present yellow-fever centres and Asia. With this more direct and more rapid communication there will arise a corresponding risk of spreading yellow fever into a huge section of tropical humanity which has hitherto enjoyed exemption from one of the deadliest diseases afflicting mankind. An infected mosquito (and *Stegomyia fasciata*, according to Giles, is a good traveller), either shipped by accident or brought on board by some thoughtless or malicious person, could easily be conveyed alive to the shores of Asia, and would suffice to set, so to speak, the whole of the tropical section of the Eastern hemisphere in a blaze. The history of the spread of disease by the rapid methods of modern travel is full of examples that should serve as a warning to our rulers and responsible sanitary authorities. Let us hope that before the central American canal is completed this important matter will receive the attention it demands, and that due care will be exercised that America does not reciprocate the introduction of cholera from Asia by a return gift of yellow fever."

RHYNCHOTA.

(Hemiptera).—Bugs.

Two pairs of wings, the upper hyaline at the apical half only or both hyaline throughout, with few veins. Mouth-parts suctorial. Antennæ simple. Metamorphosis simple, the wings developed outside the body, the nymphal and imaginal stages little differentiated and of almost equal duration and importance in most forms. The order includes only insects whose nourishment is the sap of plants, or the blood of vertebrate animals or insects obtained by suction.

The most characteristic feature of these insects is the suctorial beak, in which the lower lip (labium) forms a sheath for the mandibles and maxillæ which are the actual sharp piercing organs; applying the tip of the "beak" to the plant or insect, the setæ are pushed in, the "beak" tself not entering the tissues but only the setæ; the semi-tubular labium is partly covered at the base with the more or less elongated upper lip (*labrum*).

The order is a large and distinct one, but it includes a greater variety of forms than perhaps should be included in the limits of one order. It is commonly divided into two sub-orders *Heteroptera* and *Homoptera*; these may be defined on two characters, first, that the tegmina are thickened at the base or are of the same texture throughout; second, that the head does not touch the coxæ or is so inflexed as to be in contact with the front coxæ. The two series are in the main distinct and there is good reason to separate the first as a distinct order, the second as not necessarily one but perhaps two or three orders. We treat them as forming three sub-orders under one order. We have explained below the grounds for treating *Phytophthires* as a distinct sub order :—

	Sub-orders.	Divisions.	Families.
Rhynchota	Heteroptera	Gymnocerata (land)	1—19.
		Cryptocerata (aquatic)	20—25.
	Homoptera	Trimera (Freeliving)	26—30.
	Phytophthires.	Dimera (Semiparasitic)	31—33.
		Monomera (Parasitic)	34.

For details as to the classification and of individual species the student should consult Distant's volumes on the Fauna of India, first reading the introduction and familiarising himself with the terms used. These enumerate the Indian forms as far as the Jassidæ; all literature references will be found in these volumes, but we may remark that little has been recorded on the habits of Indian Rhynchota and that Atkinson is almost the only author in India who has published papers on the group.

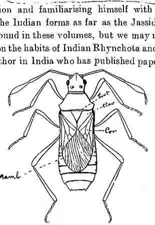


Fig. 435—HOMŒOCERUS. SCUT = SCUTELLUM. CLAV = CLAVUS. COR = CORIUM. ROST = ROSTRUM. OD. AP. = ODORIFEROUS APERTURES.

The characters used in separating families relate to the antennæ and hemelytra. The terms used are shown in figures 435 and 436; the student wishing to identify species will find the terms used in the Fauna of India fully explained in Volume 1 of Rhynchota: we have used this as the basis of classification throughout the group.

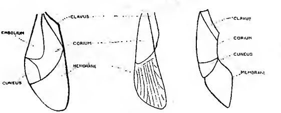


Fig. 436—WINGS OF HETEROPTERA.

HETEROPTERA.

Front of head not touching the coxæ. The tegmina usually lie flat on the abdomen and the basal half is thickened.

The sub-order falls into distinct series, the first, *Gymnocerata*, having conspicuous antennæ, the second, *Cryptocerata*, having the antennæ more or less concealed; the former includes all the terrestrial *Heteroptera*, and those that live on the surface of water; the latter includes all the Heteroptera that live in water as well as one species living on mud (*Pelogonus*) and a few on land (*Mononyx*). The sub-orders are thus easily recognised in the field. A key to the families will be found in the Fauna of India, Rhynchota, Volume I.

A feature of the great majority of the Heteroptera is the aromatic odour they protect themselves with. This odour is due to the secretion by special glands of an oily fluid, which is excreted at will from the odoriferous orifices and rapidly volatilises. The odours are very marked in *Pentatomidæ*, *Coreidæ*, *Lygæidæ*, *Pyrhocoridæ*, some *Reduviidæ*, and in *Cimicidæ*: they are ordinarily characteristic of the plant-feeding groups, only a few of the predaceous *Reduviidæ* having them. Throughout the Heteroptera, the imago is a very important and active stage of life, the previous development being practically only a growth in size, with the gradual development of wings. There is none of the specialisation of periods seen in *Lepidoptera*, *Coleoptera* and *Hymenoptera*. The nymph, as it comes from the egg, has much the same habits and structure as the adult and the changes at the separate moults are very small. The most noticeable change at the last moult, next to the assumption of functional wings, is the change in the position of odoriferous glands, one new pair becoming functional on the ventral surface of the thorax, in place of the two pairs on the dorsal surface of the abdomen. The final moult does not imply sexual maturity, but the development of the sexual organs continues for some time and a period considerably longer than the nymphal period may elapse before the sexual organs are really mature.

There is thus no metamorphosis and though we may find, in the young nymph especially, habits and colouring which it loses in a later instar, the change is not an abrupt one. Details of the metamorphosis of few *Heteroptera* are known in India, but there is a certain amount on record and a good deal more not yet placed on record. There are practical difficulties in observing the nymphal life, but these can be overcome in the case of plant-feeding species.

PENTATOMIDÆ.

Scutellum large.

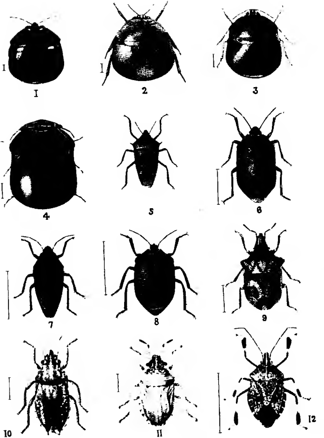
Pentatomid bugs are recognisable at sight by the large scutellum and the mouthparts, even where the resemblance to a beetle is noticeable: beginners will certainly confuse them on superficial examination. They are insects of moderate size, from a quarter of an inch to over an inch in length, robustly built and with hard integument. Colours are of great variety, black, brown, grey and other sombre colours in a large number, green and shades of dull yellow in others, bright colours in a few only. The colour is often cryptic, in some apparently warning, and in the species which live in the soil is the sombre colouration characteristic of most insects in that situation. The form of the body is not modified for cryptic purposes and there are only occasionally spines, etc., on the integument which are adapted to this end, or which serve some obscure function, possibly in rendering the insect distasteful.

The antennæ are five or four-jointed, simple. The head is flattened, usually a little produced anteriorly, with small compound eyes and ocelli. The rostrum is straight, lying against the prosternum. The prothorax is well developed, accurately fitted to the mesosternum and

PLATE LXXII.—PENTATOMIDÆ.

Fig. 1. Coptosoma siamicum. (Plataspidinæ).
,, 2. ,, testaceum. ,,
,, 3. ,, cribrarium. ,,
,, 4. Brachyplatys subaeneus. ,,
,, 5. Cantao ocellatus. (Scutellerinæ).
,, 6. Chrysocoris stollii. ,,
,, 7. Scutellera nobilis. ,,
,, 8. Poecilocoris Hardwicki. ,,
,, 9. Hotea curculionides. ,,
,, 10 Alphocoris lixoides. ,,
,, 11. Podops dentatus. (Graphosomatinæ).
,, 12. Erthesina fullo. (Pentatominæ).

(Plate painted by D. N. Bagchi, Indian Museum, Calcutta.)



PENTATOMIDAE I.

hemelytra: the scutellum is large, either covering the whole abdomen, or occupying a large portion of the base of the abdomen between the hemelytra. In the former case the hemelytra, protected by the scutellum, are not thickened at the base but are membranous throughout. The hemelytra fit closely to the abdomen, the apical membranous half of each overlapping. The lower wings are below the hemelytra and both pairs function in flight. Wingless species with abbreviated or much reduced hemelytra occur. There are small orifices of the scent-glands on the ventral surface of the thorax, whose position is useful in the discrimination of genera. The abdomen is short and thickset, its margin in some cases is visible from above and not covered by the hemelytra. The integument of the whole body is so rigid that the relative positions of the parts are accurately maintained and are useful in classification, a statement that can be made only in the case of this family, and the *Coleoptera*. Males and females are commonly similar in external appearance, the former sometimes smaller.

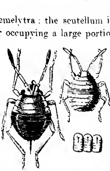


Fig. 437—SCUTELLERA NOBILIS, EGGS AND NYMPHS. (*After de Nicéville*).

The life-history is similar throughout the family. Eggs are laid in clusters on plants or elsewhere in the open; these eggs are commonly of the shape of an upright cylinder, about one-tenth of an inch high, with a flat cover on the top (like a barrel). When they hatch, this cover opens, either being attached at one side or coming completely off. The young insect is flattened, the body nearly round, and is active. It feeds on the juice of plants and passes through a number of moults with the gradual development of wings, etc., till it is full grown. The tarsi usually have only two joints, the third developing at the last moult; the odoriferous glands are in the abdomen and open on the dorsum at the apex of the third and fourth abdominal segments. The colouring of these young insects is commonly different to that of the adult and often very striking. The number of moults is usually five; the nymphal life is commonly short, the imaginal being the long and active period to which the nymphal is subordinated. The adults are found upon plants, upon trees, among grass, under fallen leaves and in decaying vegetation. Many are diurnal, brightly coloured species which live exposed on plants, many are nocturnal, especially the dark coloured species which live in thick grass or under leaves. Many have special foodplants upon which they feed principally or wholly and to which they are specially adapted ; in a few the foodplants appear to be numerous. Whilst the majority are plant-sucking, extracting the sap of green plants, a number (*Amyoteinæ*) are known to be wholly or partly predaceous on insects, sucking the fluids from their bodies. This habit is found in the nymphs as in the adults. Not a great deal has been observed on this point, but so far as observation has gone the greater number of these insects are herbivorous and only few predaceous. In particular the food of the species found on the bark of trees, under fallen leaves, among decaying vegetation, is uncertain. A small number are almost wholly burrowing insects, living in the soil and spending their whole life there, emerging only at night. Very little is yet known of these forms, which may prove to be comparatively numerous. These insects are most abundant during the rains when vegetation is in active growth, and a number of species probably breed only at this time. As a whole, it is probably correct to say that the majority of Pentatomids hibernate and æstivate as adults, laying eggs in the rains ; there are one or two broods during these months and the imagines in November hide away for the winter. There are also species which breed most actively in the cold weather and hide away in the rains. A number become active and breed during the dry hot weather if food is available, and these become very numerous in irrigated crops. The conditions of hibernation and æstivation are determined by the degree of cold and moisture in each season as well as by the abundance of food, and this varies with different tracts ; the student may, however, remember that

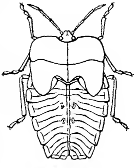


Fig. 438—TESSARATOMA JAVANICA NYMPH.

the adult is the resting stage and that even in hot weather, they live for long periods waiting until food is plentiful enough to admit of their producing eggs and of the young surviving.

Pentatomids are, in spite of their abundance and herbivorous habits, rarely destructive to crops. The reason is that the individual bugs do not extract sufficient sap from one plant or one twig to do harm, but they move about from plant to plant, sucking here and there, and not weakening the plant. It is only when they are exceptionally abundant or when they attack specially susceptible parts (*e.g.*, developing grain heads), that they are destructive. Of the number of common species mentioned below, none are major pests, a few are minor occasional pests of little importance.

The Pentatomids appear to be protected by the powerful scent produced by the scent-glands, as are most *Heteroptera*. This scent which is the volatilised oil, has a very strong effect on many animals and probably on predaceous insects; it is apparently not a complete protection as wasps and mantids have been observed to eat Pentatomids. The eggs are parasitised by *Chalcidæ*, which constitute one check; other checks are the slow reproduction and the limited duration of the seasons when abundant food makes reproduction possible.

Pentatomidæ are one of the largest families of the order, spread over the tropical and temperate zones, most abundant in tropical regions. The Indian fauna is Indo-Malayan mostly, with a number of Palæarctic hill forms which extend into the north and with the larger number of species known only from hill or submontane forest localities. The known plains fauna is a fraction only of the whole, though our knowledge of the plains species is defective and it is probable that the number of species in the plains is nearly as large as that of the sub-tropical forest and hill areas. The student will find descriptions of the Indian fauna in Distant's Rhynchota in the Fauna of India, wherein 542 species are described with the addition of 46 species in the appendix to Volume IV. The 11 sub-families can be made out without difficulty, but the subsequent classification and recognition of species is at first difficult without the aid of a good reference collection.

Plataspidinæ.—The scutellum completely covers the abdomen, the hemelytra being folded away underneath. These little insects are clearly distinguishable and are fairly common. *Brachyplatys* and

Coptosoma include the species common in the plains, species which are distinguishable only with some care (Plate LXXII, figs. 1—4).

B. subaëneus, Westw., is the most widely spread species of the former genus, and has been found destructive in one instance to jute plants and also to feed specially upon val (*Dolichos lablab*). *Coptosoma cribrarium*, Fabr., is widespread and perhaps the most generally distributed insect of this sub-family. Like the preceding species, this has a habit of clustering gregariously on growing plants, specially on the stems of such plants as jute and val (*Dolichos lablab*) which are growing freely. Though very common, none appear to be pests since they do not confine their attacks to individual plants for a sufficiently long time to do harm. *C. siamicum*, Wlk., is widespread and common, appearing in abundance in the rains among dense vegetation. The life-history of no species has been worked out, and though these insects are most common in the rains, they have been found at all seasons of the year.

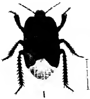
It is a curious fact that, while the adults are commonly found exposed on plants, the nymphs are not, and it is probable that nymphs of this group live wholly in concealment at the surface of the soil or at the roots of plants. This applies very markedly to this sub-family and also to a large majority of the whole family; the species whose nymphs are found living an open life is comparatively small and it will be interesting to learn details of the life of these concealed nymphs.

Scutellerinæ.—The obvious character that distinguishes this sub-family is the extension of the scutellum over the hemelytra, the latter not being long and folded as in the previous sub-family but straight. The extreme base of the outer margin is alone not covered by the scutellum. The insects are larger, more brightly coloured and without the peculiar facies of the previous sub-family (Plate LXXII, figs. 5—10). *Cantao ocellatus*, Thunb., is commonly found upon trees or vegetation and in the fields during the rains. The female has been found to lay a number of eggs on a leaf and to sit over the eggs until they are hatched. The insect is common both in the plains and the hills. *Pœcilocoris* includes large brightly-coloured species rarely found in the plains. *Scutellera* includes plains species, the metallic green or blue insects found among vegetation. *S. nobilis*, Fabr., is the usual species. de

PLATE LXXIII.—PENTATOMIDÆ.

Fig. 1. Brachypelta aterrima. (Cydninæ).
,, 2. Stibaropus molginus. ,,
,, 3. Cydnus indicus. ,,
,, 4. Halys dentatus. (Pentatominæ).
,, 5. Eusarcocoris guttiger. ,,
,, 6. Hoplistodera virescens. ,,
,, 7. Halyomorpha picus. ,,
,, 8. Plautia fimbriata. ,,
,, 9. Agonoscelis nubila. ,,
,, 10. Dolycoris indicus. ,,
,, 11. Antestia anchora. ,,
,, 12. Bagrada picta. ,,

(Plate painted by D. N. Bagchi, Indian Museum, Calcutta.)



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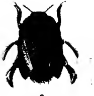

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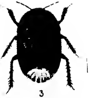

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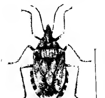

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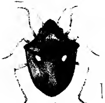

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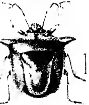

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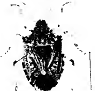

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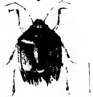

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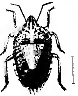

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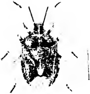

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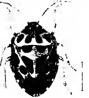

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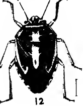


12

PENTATOMIDAE II.

Nicéville records this as attacking grave vines and figures the eggs and nymphs (Indian Museum Notes, V, p. 119).

Chrysocoris stollii, Wolff, is closely similar and equally general. It has been found among forest trees and in dense vegetation. Its life-history is briefly described by Kershaw and Kirkaldy as seen in S. China (Trans. Ent. Soc., London, 1908, p. 59). *Chrysocoris purpureus*, Westw., and *C. marginellus*, Westw., are stated by R. M. Dixon to be injurious in gardens. The former breeds freely on *Jatropha curcas*, a common bush; it is familiar in South India, where children know it and catch it to play with.

Hotea curculionides, Herr. Sch., is a brown species, with a resemblance to a weevil, found among dead leaves under large trees. The nature of its food is unknown. *Alphocoris lixoides*, Germ., has a still more marked resemblance; it is found so rarely its habits have not been observed. *Arctocoris incisus*, Stal., is a small dark form, with the pronotum deeply transversely impressed and the whole body and scutellum densely clothed in long hairs. It is found in the loose surface soil in Behar and is seen but seldom.

Graphosomatinæ.—In these the scutellum is long, but the basal and outer margins of the corium are exposed and sometimes the apex of the abdomen (Plate LXXII, fig. 11). Four species have been found in Behar, under leaves in the fields or jungle, though all are recorded by Distant from the hills alone. These are all dull brown or black species, the typical colouring of insects which live a concealed life on the surface of the soil under leaves. They are *Storthecoris nigriceps*, Horv., *Amauropepla denticulata*, Hagl., *Melanophara spinifera*, Westw., and *Podops coarctata*, Fabr. All are likely to be found if surface insects are being collected in the plains. The first two are to be found at the roots of sugarcane where also their nymphs occur. The last was reported as injurious to rice in the Salem district in July, 1907, with *Tetroda histeroides*, Fabr., the only known case of this species being destructive.

Cydninæ.—Almost the whole of the basal ventral segment is covered by the metasternum. These are deep brown or black insects of moderate size, found under stones among fallen leaves at the surface of the soil, in dense vegetation or in the soil itself. Some are notorious owing to their habit of coming in immense numbers to lights at night, and as their odour is a very powerful and aromatic one, they are a distinct nuisance in the rains. As they are otherwise but seldom seen and are not found unless looked for, few species are recorded as general.

The most remarkable form is *Stibaropus molginus*, Schi., a moderately large dark brown insect, with a very close resemblance to a Melolonthid beetle and remarkable legs. The femora and tibiæ are swollen, very much so in the hind legs, and suggest the burrowing legs of the Coprid beetles, with the difference that the maximum development lies in the hind legs, which are very thick and truncate. The remarkable white nymphs of this insect were found by C. A. Barber at the roots of a palm in S. India at a considerable depth below the surface. They have the same burrowing legs as the adult. This insect is less common than the smaller *S. callidus*, Schi., found in the plains of Bengal: the adult insect flies at night and is also found among the roots of plants; it is typically a burrowing insect. We have found it extraordinarily abundant on the Ferry Steamers on the Ganges attracted by the electric lights and it appears to be most common near large rivers in loamy soil (Plate LXXIII, fig. 2). *Cydnus* includes the common black "geranium bugs" or "gundies" which are so great a nuisance (Plate LXXIII, fig. 3). *C. indicus*, Westw., and *C. varians*, Fabr., appear to be the usual species found. Their normal habitat is on or in the soil, but at certain seasons in the rainy months, they come out in great abundance possibly because they are flooded out by excess of rain, possibly because this is their normal habit.

Geotomus pygmæus, Dall., is a smaller species, less commonly found, but still likely to be generally distributed. The only other common Cydnid is *Brachypelta aterrima*, Forst., larger than *Cydnus*, coal black in colour and found in the fields especially in the early months of the year (Plate LXXIII, fig. 1).

Chilocoris nitidus, Mayr., is one of the smallest of the group, a black insect measuring only ⅛th inch in length. The flat head is set round the margin with spines and suggests that of a Coprid beetle; it is found in soil, under stones or among decaying vegetation. Apparently it breeds normally at the roots of grasses, the nymphs having been extensively found there.

Pentatominæ.—An extensive sub-family, with a distinctive facies and usually recognisable, but whose divisions are complex and should be studied with care in Distant's volume. This includes the largest number of common species, of which we can mention only a few. *Erthesina fullo*, Thunb. (Plate LXXII, fig. 12), and *Halys dentatus*, Fabr. (Plate LXXIII, fig. 4), are two large dull coloured species with rather elongated head, the former with flattened tibiæ. They are commonly found upon the bark of trees and there is some reason to believe they are predaceous habitually or occasionally.

Dolycoris indicus, Stal. (Plate LXXIII, fig. 10), appears to be the most universal of the Pentatomids in the cultivated plains. It is found, with *Agonoscelis nubila*, commonly upon crops, especially jute, lucerne, maize, juar and similar green crops, while it ocasionally attacks ripening heads of juar and other millets. It is plant-feeding, but no instance of serious destruction caused by it has yet been recorded.

Eusarcocoris includes small bugs of rounded form, similar to *Coptosoma* with the scutellum rather large and prominent. These are found upon plants (Plate LXXIII, fig. 5). *E. guttiger*, Thunb., and *E. ventralis*, Westw., are the common plains species.

Plautia fimbriata, Fabr. (Plate LXXIII, fig. 8), is a green species, the hemelytra deep reddish, found on plants in the hills and plains and widely distributed. *Antestia*, *Eurydema*, *Stenogyzum*, *Bagrada* and *Strachia* include brightly coloured insects of a similar facies, marked in red or yellow upon black (Plate LXXIII, figs. 11, 12, Plate LXXIV, fig. 1). *A. anchora*, Thunb., and *A. cruciata*, Fabr., are hill species, the latter destructive to coffee berries and reported as destructive to garden plants and fruit. *E. pulchrum*, Westw., though mainly a hill form, is certainly found in Behar and may extend further. It feeds upon

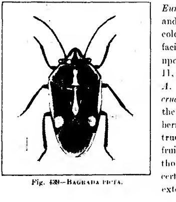


Fig. 439.—BAGRADA PICTA.

cultivated rape, mustard and allied plants. *Stenogyzum speciosum*, Dall., is a smaller insect, found in widely scattered localities. *Bagrada picta*, Fabr., is the widespread and abundant species, which perhaps comes nearest of all this family to being a pest, large numbers being occasionally found upon rabi cruciferous crops. It was strikingly abundant over North India in the early months of 1909. *Strachia crucigera*, Hahn., is a Malayan form found also in the Assam Hills and the valleys of Assam and Eastern Bengal, feeding also upon Cruciferæ.

Agonoscelis nubila, Fabr. (Plate LXXIII, fig. 9), is an ochreous species with a very close resemblance to *Dolycoris indicus*, with which it is constantly found upon field crops. (The distinction between these remarkably similar species is that in *Dolycoris* the margin of the abdomen shows beyond the margin of the wing ; in *Agonoscelis*, the wing completely covers the margin of the abdomen.)

Catacanthus incarnatus, Dru. (Plate LXXIV, fig. 4), is a large and brilliant insect, of a bright red or orange colour, the margins of the abdomen projecting at the sides and banded in yellow and black, much increasing the brilliant effect of the colouring. This is not a common insect and probably increases slowly but is widespread over the plains.

Nezara viridula, Linn., is the familiar green bug so common on potato plants, which is now distributed almost over the whole world. It is a uniform leaf green colour above, in some with a lighter blotch behind the head (fig. 440) or yellow with only green spots. It is common on low crops and can scarcely be reckoned as a pest. *Piezodorus rubrofasciatus*, Fabr. (Plate LXXIV, fig. 10), is a smaller species, paler and duller in colour and often straw coloured, which is very abundant among low crops and is obtainable in quantity on irrigated crops, especially lucerne and senji, in the hot weather.

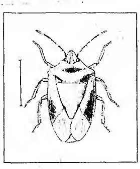


Fig. 440—NEZARA VIRIDULA.

Amyoteinæ (*Asopinæ*).—*Cazira verrucosa*, Westw., is an insect of somewhat remarkable appearance with a long dilated femur on the foreleg. Like others of this division it is a predaceous insect, with a foreleg approaching in function and structure to that of the Mantidæ. *Canthecona furcellata*, Wolff. (Plate LXXIV, fig. 2), is another form with somewhat the appearance of *Dolycoris indicus*, but with the lateral angles of the pronotum spined. It is found upon crop plants in company with *Dolycoris indicas*, and *Agonoscelis nubila*, but is markedly predaceous and can readily be seen to suck out caterpillars and other small insects. We found it breeding abundantly in a plot of bariar (*Sida rhombifolia*) in which caterpillars were particularly abundant, and it is usually found breeding in such situations. In the intervals of such abundance of food, the imago appears to lead a precarious life of search for food. It has proved a very serious enemy to the cultivation of tussur silkworms in the open; large numbers of the bugs came to the bushes on which the worms were and, in spite of constant destruction, managed to search out and kill many worms. It is probable they play a very important part in checking caterpillars generally. *Andrallus* (*Audinetia*) *spinidens*, Fabr., is a rarer insect, which feeds upon larvæ of *Thermesia rubricans* and other caterpillars, which is equally found among herbage and low crops (Plate LXXIV, fig. 5). *Amyotea* (*Asopus*) *malabaricus*, Fabr., is a bright red insect with black markings found occasionally upon cultivated plants.

The life-history of *Zicrona cœrulea* is described by Kershaw and Kirkaldy (Journ., Bombay Nat. Hist. Soc., XIX, No. 1, 1909); it is found in China to feed on the beetle *Haltica cœrulea*, Oliv., the nymphs feeding on the larvæ, the adults on the beetles. (The author's use of *Cimicidæ* for *Pentatomidæ* in that paper will confuse the student unless he knows that Mr. Kirkaldy uses *Cimicidæ* as the correct name for *Pentatomidæ* and *Khinophilos* or *Acanthia* for *Cimex*, a practice followed by this author and a few others.)

Tessaratominæ.—*Tessaratoma javanica*, Thunb. (Plate LXXIV, fig. 8), is a large brown bug over an inch long, found upon trees. Mr. Dixon has observed that it produces a loud shrill noise when seized. We figure it in its nymphal form when it is extremely flattened and leaflike (fig. 352) of the delicate red colour of many young leaves; it is common in hill localities. The bug is remarkable as having a stridulating organ in both sexes. Its life-history and stridulating organ are figured and described by Kershaw and Muir (Trans. Ent. Soc., London, 1907, p. 253).

Dinidorinæ. The scutellum small, membrane large. *Cyclopelta* includes several species of which *C. siccifolia*, Westw. (Plate LXXIV, fig. 11), appears to be the most common. This insect is found feeding upon cultivated pulses, and its eggs are laid in clusters upon the shoots. *Aspongopus* includes several closely similar species of which there are three common generally. *A. janus*, F.. has the pronotum and base of elytra bright red, the head, base of scutellum and membrane of wings black (Plate LXXIV, fig. 3). *A. brunneus*, Thunb., and *A. obscurus*, F., are dull brown above, the former with the abdomen above (under the wings), red, the latter with it black. These insects are commonly found on low crops, among roots, stones, etc. One species, *A. nepalensis*, Westw.. is stated to be used as food by natives of Assam, pounded with rice. (Garman in Distant.) It is probable that the insect gives a powerful aromatic flavour to the rice. *Megymenum parallelum*, Voll., is one of the many black bugs found among fallen leaves, stones, etc., of whose food nothing is known.

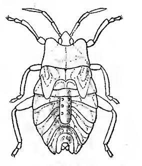


Fig. 441—TESSARATOMA PAPILLOSA DR. NYMPH

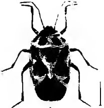
Phyllocephalinæ.—This sub-family includes few common species, characterised by the markedly lobate head. The single species *Randolotus elongatus*, Dist., with the three species (*M. rostratus*, Fabr., *M. truncatus*, Westw., *M. limatus*, Herr Sch.) of *Megarhynchus* appear to be far more general than the recorded distribution would show. They are of peculiar "dry grass" colour as befits their habitat and are typically inhabitants of long dry grass in waste lands. (Plate LXXIV, fig. 9.) *Tetroda histeroides*, Fabr., is a black species, sent from Salem as a pest of rice, with *Podops coarctata*, F.

Urostylinæ.—Three genera of insects not common generally. *Urolabida* is without ocelli, and includes the only common species *U. histrionica*, Westw., a greenish insect with dull yellow markings, with long antennæ and short rostrum (Plate LXXIV, fig. 6); the bug is found upon the leaves of trees and is known from the Himalayas and places

PLATE LXXIV.—PENTATOMIDÆ.

Fig. 1. Eurydema pulchrum. (Pentatominae).
,, 2. Canthecona furcellata. (Asopinae).
,, 3. Aspongopus janus. (Dinidorinae).
,, 4. Catacanthus incarnatus. (Pentatominae).
,, 5. Audinetia spinidens. (Asopinae).
,, 6. Urolabida histrionica. (Urostylinae).
,, 7. Placosternum dama. (Pentatominae).
,, 8. Tessaratoma javanica. (Tessaratominae).
,, 9. Megarhynchus rostratus. (Phyllocephalinae).
,, 10. Piezodorus rubrofasciatus. (Pentatominae).
,, 11. Cyclopelta siccifolia. (Dinidorinae).
,, 12. Elasmostethus recurva. (Acanthosomatinae).

(Plate painted by D. N. Bagchi, Indian Museum, Calcutta.)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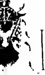
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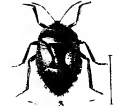
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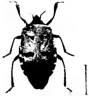
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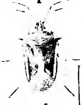
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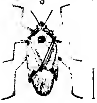
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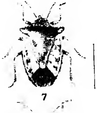
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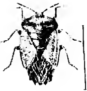
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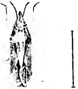
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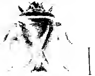
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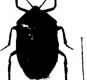
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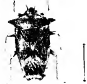
12

PENTATOMIDAE III.

in the Gangetic valley and delta. *Urostylis punctigera*, Westd., and *Urochela quadripunctata*, Dall., are also found rarely in the plains.

Acanthosomatinæ.—Are distinguished by the tarsi being two-jointed. *Microdeuterus* is represented by two species, sparingly found. *Acanthosoma. Sastragala* and *Anaxandra* have the pronotal angles prominent or spined; there are a number of species, widely spread and rare. *Elasmostethus recurvum*, Dall. (Plate LXXIV. fig. 12), and others of this genus will also be found.

Collecting.—Pentatomids are obtained by sweeping and beating vegetation, by ordinary searching on plants, among grass and low herbage, on the bark of trees, under dead leaves and decaying vegetation. Some come to light. Rearing is easy only if the living plant can be provided and maintained in vigour to supply the plant sap. When captured they may be killed in a Cyanide or B. C. bottle and pinned through the scutellum or right hemelytron. Wings need not usually be set.

What is principally required in this family is accurate observation as to the food-plants of the nymphs and adults; very little is known and prolonged observation is usually required to determine what the food really is. Another interesting problem is that connected with breeding and seasonal appearance: very little is known as to the seasons at which these insects breed or what checks their increase, and since all the common species can readily be determined with the aid of Distant's volume, there is here a large field for observation.

COREIDÆ.

Antennæ inserted above a line drawn from the eyes to the base of the rostrum. Scutellum small. Rostrum not curved.

In almost all cases, this family is immediately recognisable from its very distinctive facies. In doubtful cases, such as the red *Serinetha*, the characters must be carefully verified. They are insects of moderate to large size for the order, with a length of one quarter to one and a half inches. Some are heavily built and massive, others slender. Colouring is nearly always dull, the "dead leaf" colour very common in the large forms, green or dry grass colour in smaller forms. *Serinetha* and a few others are brightly coloured.

The head is small, deeply set in the large prothorax with four-jointed and moderately long antennæ and a straight four-jointed rostrum extending in repose along the ventral surface of the body. The prothorax is large and is often produced into processes or spines at the lateral angles; in some cases these processes are large and rather grotesque (Plate LXXVI, figs. 6, 7); with these are also leaflike expansions of the legs, especially the hind legs, and of the antennæ, while the abdomen is laterally expanded in a smaller number. These leaflike expansions are accompanied by the "dead leaf" colouration, the deep dull brown of the dead fallen leaves. It is perhaps useless to speculate as to the value of these expansions, but the sight of these curious insects among green plants or on trees suggests a dead leaf, while on bark or among fallen leaves the insects are very difficult to see. In our opinion these insects are so formed as to suggest a fallen leaf when feeding on green vegetation and are concealed when at rest on bark, or among fallen leaves. The hemelytra cover the wings, which lie flat on the abdomen, the dorsal surface of the latter being often brightly coloured; as this colour is exposed in flight, there is a marked form of "deceptive colouring" in some forms (see page 90).

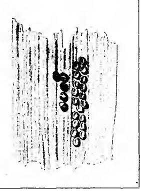

Fig. 442—Leptocorisa varicornis eggs ×2.

The details of the life-history are known in only a very few forms. (Plate LXXV). The eggs are of two types: (1) oval, flattened and unornamented (fig. 442), the insect emerging through an aperture in the flat upper surface (*Leptocorisa*, *etc.*): (2) more elongated, the upper surface not flattened, the insect emerging from the upper surface near one end (*Homœocerus*, *Clavigralla*.) The exact mechanism of the rupture of these eggs remains to be learnt. The eggs are laid in irregular clusters openly on the food-plant and are parasitised by Chalcidæ. The number of moults observed in *Leptocorisa varicornis* is five, the wing lobes appearing at the third. The stink-glands in the nymph are situated on the dorsal surface of the abdomen, the tarsi are two-jointed. The nymphs appear to have the same habits as the adults. There is very little on record as to the food of these insects though what is known points to them being exclusively feeders on plant sap. Whether they have special food-plants or not is scarcely known: our common species have special food-plants among crops and probably all feed only on particular plants and their increase and spread is, therefore, dependent upon their food-plants. One only is a real pest in India, the Rice bug, *Leptocorisa varicornis*, Fabr., injuring the developing seed of rice, and millets. Like other *Heteroptera* their scent is not the least striking feature of them and though these scents are not wholly disagreeable, they are powerful. A rice field infested by *Leptocorisa* can sometimes be known from afar and it is probable that the scent is ordinarily a protection.

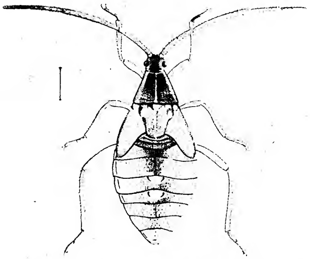

Fig. 443—HOMŒOCERUS INORNATUS. NYMPH.

Distant enumerates 143 species as Indian, adding 33 in the appendix to Volume IV, principally hill and forest species. A small number are common and abundant in the plains and a further small number are found here and there where abundant trees and vegetation offer food and shelter. Four sub-families are recognised, distinguished by the troublesome and obscure characters that Hemipterists choose for the purpose of classification and which we omit in this place. The student may see them in Volume I of the Rhynchota, in the Fauna of India.

Coreinæ include a large number of the large brown species with dilated legs and expanded pronota found principally in tbe hills. *Anoplocnemis phasiana*, Fabr., is the commonest species and is found rarely in the plains, mainly in the hilly localities. It is said to live on *Erythrina* and occurs also on shrubs and grass in many parts of India where the vegetation is sufficiently abundant. *Dalader* has the abdomen much produced laterally, and, like the remainder, is the colour of a dead leaf. Apparently the expansions of legs, antennæ, pronotum and abdomen found in these insects are designed to give tbe insect a resemblance to a dead leaf, but it is far less efficiently effected than in the Lepidoptera and Orthoptera. *Dalader acuticosta*, Am. et Serv., and *D. planiventris*, Westd., are the common species, neither found abundantly.

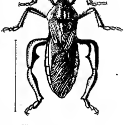

Fig 444—ANOPLOCNEMIS PHASIANA.

In *Homœocerus* (Plate LXXVI, fig. 8) this type gives place to a less grotesque-looking form, without leaf-like expansions. This genus includes many species closely similar, some of which are found commonly on trees in the plains. It is not easy to discriminate individual species without the aid of a named collection. Of the 33 species recorded by Distant, less than ten are found in the plains and these only occasionally. Some feed on weeds (*H. variabilis*. Dall.), others on such trees as Sissoo (*H. inornatus*, Stal., *H. lævilineus*, Stal.). The latter are not uncommon where this tree grows, the nymphs being of the delicate green of the leaves among which they feed. *H. inornatus* sits near the end of a twig, and the green colouring with the dull black of the membrane suggests a leaf withered at the tip, as is so often seen on Sissu leaves when the weevil *Apoderus* has been at work.

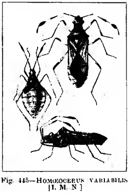

Fig. 445—HOMŒOCERUS VARIABILIS. [I. M. N.]

There are a number of other genera and species, all of which are typically hill and forest species, found but rarely in the plains. *Physomerus grossipes*, Fabr., is one of the few plains species, a dull brown insect with thick curved dark-banded hind femora. *Acanthocoris scabrator*, Fabr. (Plate LXXVI, fig. 10), is also found rarely; in this the abdomen projects laterally beyond the hemelytra. *Cletus* includes several species of smaller thickset insects with slightly produced lateral pronotal angles, found commonly in crops in the plains. None are injurious. Five species may be found in the plains and they are not easy to distinguish. *C. bipunctatus*, Westd., appears to be the most common. (Plate LXXVI, fig. 12.) *Cletomorpha* resembles *Cletus*, but has the abdomen produced laterally. *C. hastata*, Fabr., is rarely found. (Plate LXXVI, fig. 11.)

Pseudophlœinæ.—*Clavigralla* includes two species, *C. gibbosa*, Spin., and *C. horrens*, Dohrn., which live on leguminous crops and suck the juice. They are not injurious, though sometimes abundant on tur (*Cajanus indicus*). Their small reddish-brown eggs are frequently found in clusters on the pods of this plant. (Plate LXXV.) *Stenocephalus lateralis*, Chenn., is a graceful dark-coloured bug with a lateral light stripe on the hemelytra, found occasionally in abundance on low plants.

Alydinæ.—*Dulichius inflatus*, Kby., is the remarkable bug which attracted attention from its resemblance to an ant, *Polyrhachis spiniger*. Wroughton drew attention to this (Proc. Ent. Soc., London, 1891, p. xvii) and Rothney stated that where this ant lives on trees the bug is also arboreal and not, as Wroughton found, on the surface under stones.

Leptocorisa varicornis, Fabr., is the rice bug, whose prevalence in rice and millet fields as the grain forms is a serious matter for the cultivator. The life-history is dealt with elsewhere. (Mem. Dept. Agric., Vol. II, No. 1.) This insect, while living normally among grass and thick vegetation, multiplies very largely in rice fields and is one of the few distinctly injurious *Heteroptera*.

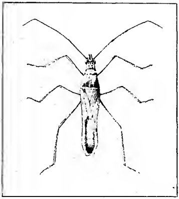

Fig. 446—LEPTOCORISA VARICORNIS × 2

Riptortus (Plate LXXVI, figs. 1—5) includes several species of narrow brown insects, found flying among grass in jungle, in crops. They are common among leguminous crops such as the minor pulses grown with other crops and have been seen to suck the pods. *R. linearis*, Fabr., appears to be the most common species. Its life-history is shortly described by Kershaw and Kirkaldy (Trans. Ent. Soc., London, 1908, p. 59).

Corizinæ.—Corizus bengalensis, Dall., is common especially upon Bhindi (*Hibiscus esculentus*) upon which it can commonly be found during the hot weather and rains. It is a small but peculiarly elegant insect, of very active habits and is, at least in part, plant feeding, extracting the sap and mucilage of its food-plant. It is found throughout India from the Punjab to Madras. *C. rubicundus*, Sign., also occurs in the plains of India with the above species. The nymphs are dark red with white speckles, the newly emerged adults are bright red at first, gradually growing dark-coloured. These insects cluster in masses on the buds of *Pentapetes indica* and give the same appearance as do the vivid red flowers of the plant. (Plate LXXVI, fig. 13.)

Serinetha includes two red species which will be confused with *Pyrrhocoridæ* and which are the only brightly coloured species likely to be found. *S. abdominalis*, Fabr., and *S. augur*, Fabr., are both common,

PLATE LXXVI.—Coreidæ.

Fig. 1.	Riptortus linearis 1st instar	x 4.
,, 2.	,, ,, egg from side.	x 4.
,, 3.	,, ,, ,, ,, above.	x 4.
,, 4. ,, 5.	,, ,, imago.	x 4.
,, 6. ,, 7.	Derepteryx hardwicki.	x 2.
,, 8.	Homœocerus inornatus.	x 2.
,, 9.	Aschistus brevicornis.	x 2.
,, 10.	Acanthocoris scabrator.	x 2.
,, 11.	Cletomorpha raja.	x 3.
,, 12.	Cletus bipunctatus	x 3.
,, 13.	Corizus rubicundus.	x 3.

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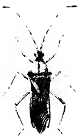

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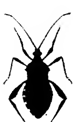

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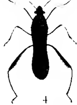

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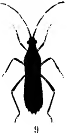

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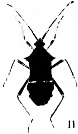

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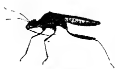

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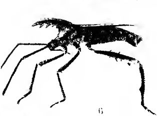

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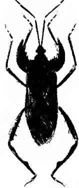

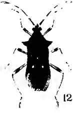

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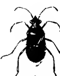

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and are frequently found upon cotton with the Red Cotton Bug (*Dysdercus cingulatus*, Fabr.); they are known not to feed on cotton seeds as this species does, and are harmless; R. M. Dixon observed one specimen of *S. augur* feeding upon another of its own species in the field, which points to carnivorous habits, and *S. abdominalis*, Fabr., has been seen feeding upon *Dysdercus cingulatus*, Fabr., which it closely resembles.

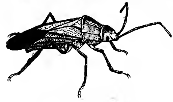


Fig. 447—SERINETHA AUGUR.

BERYTIDÆ.

Like Coreidæ but with long legs, the apices of the femora swollen.

This family includes five small delicate insects of slender build, and of great apparent rarity. They are far commoner than their recorded Indian distribution would show, but are seldom noticed or collected. *Paleologus jeanus*, Dist., was found in Burmah, *Metacanthus pulchellus*, Dall., in Northern India, *Hubertiella cardamomi*, Kirk., by E. E. Green in Ceylon, *Metatropis aurita*, Breddin, in Darjeeling and *Capys malacaipus*, Stal., in Ceylon. The unobservant student will probably think he has the little Reduviid *Lorichius umbonatus*, Dist., when he first sees these graceful insects, but he may remember that in this the base of the tibia is dilated, not the apex of the femur, even if the rostrum tells him nothing.

Metacanthus pulchellus, Dall., is the common Indian form sometimes seen in abundance upon cultivated cucurbitaceous plants. It is a slender greenish insect with the femora and antennæ swollen at the apex.

LYGÆIDÆ.

Antennæ inserted on the side of the head. Ocelli present.

A family of considerable magnitude, whose members can usually be distinguished in the field, not by any accurate characters but by family resemblance. There is no real character dividing these insects from the *Coreidæ*: no one would separate the smaller *Coreidæ* from many *Lygæidæ* (fig. 446) on the one character given, *viz.*, the position of the antennæ, and where the student has a small bug obviously possessed of ocelli, it may be either family. The *Lygæidæ* are small insects, few exceeding one-third of an inch. Some are vividly coloured with warning tints, the majority are dull earth or bark colour. The head is distinct, the antennæ moderately long, with compound eyes and ocelli. The rostrum is straight, in repose closely applied to the under-surface of the body between the legs. The legs are long, formed for active running. The hemelytra lie closely on the abdomen. Males are distinguishable only with difficulty and there are no obvious external characters.

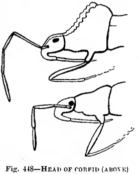


Fig. 448—Head of Coreid (above) and Lygæid.

Practically nothing is known of the life-history and food of these insects, the life-history of only one species (*Oxycarænus lætus*, Kby.), having been worked out in India. A few are plant-feeding, one is injurious to a crop plant, one is predaceous and the food of the remainder is a matter of doubt. Distant remarks that the family is an important one economically. This does not apply to India; we include only one Lygæid in our list of injurious insects, this being *Oxycarænus lætus*, Kby., the Dusky Bug of Cotton.

Distant enumerates 143 species in the Fauna of India, and has added others since (A. N. H., 1909, p. 317).

The Indian forms fall into nine sub-families as listed in the Fauna of India; it is probable that the classification of these insects will be considerably improved by revision, when more natural divisions are adopted.

Lygæinæ.—The brightly coloured forms are included here, small red and black insects common everywhere on vegetation.

Lygæus militaris, Fabr., is very common and occurs on cotton and other plants as well as on akh (*Calotropis*). It is not injurious and seldom abundant. The fore femora are armed with spines. The small oval eggs are laid in clusters on soil or on sheltered spots on the food plant, the young being red. *L. hospes*, Fabr., is smaller, without the white markings on the membrane of the hemelytra. Both are common throughout the plains.

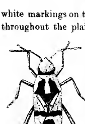


Fig. 449—Lygæus militaris × 3.

Graptostethus includes five species that may be found anywhere in the plains, of which *G. servus*, Fabr., is by far the most common. It is not injurious and there are no accurate observations as to its food. *G. trisignatus*, Dist., is common in Assam and as far west as Behar. *G. dixoni*, Dist., is abundant in the Central Provinces, as also in Bombay. *G. maculatus*, Dall., though recorded only from "North India" and Narkanda, is common in Pusa on low herbage. *Aspilocoryphus guttiger*, Dall., will be confused with *Graptostethus dixoni*, Dist.

Melanotelus bipunctatus, Dall., is a small insect found on sand dunes near the sea. *Nysius minor* Dist., is a very small delicate insect of a dull brownish colour, found abundantly on tobacco and green plants. It has been found breeding in great abundance upon the common weed, *Euphorbia pilulifera*.

Cyminæ includes two genera of small little-known insects. *Cymus tabidus*, Stal., occurs in Behar, in grass.

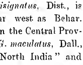


Fig. 450—Nysius minor × 4.

Blissinæ.—Macropes includes narrow parallel-sided forms in which the hemelytra fail to cover the abdomen. *M. tinctus*, Dist., appears to be common, while *M. punctatus*, Wlk., is also found. These little insects have spiny dilated forelegs and are probably predaceous. *Blissus gibbus*, Fabr., is not uncommon and is entirely harmless, found on cane, grasses, etc. Its nymphs are found at the roots of grasses.

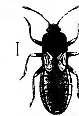


Fig. 451 Blissus gibbus, nymph. (*After Distant.*)

Geocorinæ.—Geocoris is the sole Indian genus, with small insects with broad head and thickset body. *G. tricolor*, Fabr., is the common species, found in the twisted shoots of cotton in which lives the mealy bug *Dactylopius nipæ*, Mask. It is known to be predaceous upon the bugs, but may also be vegetarian.

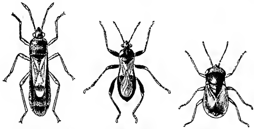


Fig. 452—MACROPES TINCTUS × 4½. BLISSUS GIBBUS × 4. GEOCORIS TRICOLOR × 4.

Colobathristinæ.—A single species will be found, the slender *Artemidorus pressus*, Dist., in which the base of the abdomen is contracted into a distinct "waist."

Heterogastrinæ.—Four rare species occur in India, and *Dinomachus rhacinus*, Dist., common on tree trunks. *Epibomius Pusa*, Dist., is also known.

Pachygronthinæ.—A single species, *Pachygrontha dixoni*, Dist., was found in Bombay.

Oxycareninæ.—The only destructive member of this family is the little Dusky Bug of Cotton, *Oxycarenus lætus*, Kby., common throughout the cotton growing areas of India. The eggs are laid in the lint near the cotton seed: the young hatch there and live till they are adult in the boll, sucking the seeds. The only other common species is *O. lugubris*, Motsch., found on low-growing plants

Aphaninæ.—This sub-family includes the greater number of species. *Pamera pallicornis*, Dall., is a common insect in grass as also is the smaller *P. vincta*, Say. The form of the prothorax with its narrowed anterior half is a guide to recognising this genus. It is probable that these little insects are predaceous. *Appolonius cincticornis*, Wlk., is a little over one-tenth of an inch long, a nearly black insect found among grass and low vegetation. *Lachnophorus singalensis*, Dohrn., will be found and there are probably many species in the allied genera not yet described, but to be found everywhere in India. *Aphanus* is commonly represented by dull brown or black bugs found among fallen leaves and in abundance

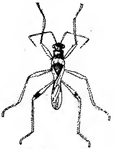


Fig. 453—ARTEMIDORUS PRESSUS. × 4

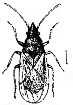


Fig. 454—OXYCARENUS LÆTUS. (*After Distant.*)

in the debris at the base of the trunk of a big tree such as a pipal (*Ficus religiosa*). *A. sordidus*, Fabr., *A. bengalensis*, Dist., and *A. orientalis*, Dist., appear to be the common species. De Nicéville's observation as to the injury caused by the former insect has never been confirmed and, apart from this one instance, these insects have not been recorded as injurious. They have, however, been found to infest threshing floors and to carry off the wheat grains to the margins of the floor and hide them. What nourishment they can extract from a dry wheat grain seems doubtful, unless their salivary excretion has solvent powers, but they carry off the grains so abundantly that the cultivators require to collect them again every morning.

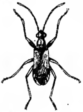


Fig. 455—PAMERA VINCTA. × 4.

Dieuches uniguttatus, Thunb., is an abundant insect among fallen leaves in grass; it resembles *Pamera* but is larger. Other species of *Dieuches* will be found, *D. leucoceras*, Wlk., being widely spread but not common. *Pæantius festivus*, Dist., is the last of these small dusky bugs found among leaves that we can mention here; it is known from Bengal and Behar but probably has a wider distribution.

Collecting.—The smaller species are found in grass, in fallen leaves, among thick vegetation and are probably much more numerous in species than the present records show. They have been very little collected in the plains and there is a large field for new work. This is true also of the bionomics of the family, the life-histories are almost wholly unknown, the food of the adults and nymphs has not been recorded and from every point of view the family have been neglected.

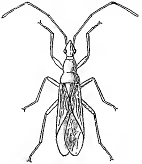


Fig. 456—Paromius seychellensis. × 3.

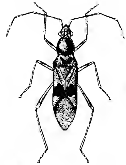


Fig. 457—Dieuches uniguttatus. × 3.

PYRRHOCORIDÆ.

Ocelli absent. Antennæ inserted on the side of the head.

This family includes a number of species usually of larger size and brighter colouring than the Lygæids. The size varies from one-quarter to nearly two inches in length. The colours are typically warning, and red is the predominant colour. All known are plant-feeding and the majority feed openly exposed on their food-plant. There are several species with the membrane of the hemelytra missing or abbreviated, and there is some amount of variation in this respect within the limits of a single species. In nearly all the sexes are similar, the males little smaller; in one species the male is marked by the great length of the abdomen (*Lohita grondis*).

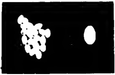
Details of the life-history are known for only one species, *Dysdercus cingulatus*, Fabr., and nothing appears to be on record as to the habits or life-history of other species. As a whole the family is not really

PLATE LXXVII.—DYSDERCUS CINGULATUS.

RED COTTON BUG.

Fig. 1. **Eggs**, natural size and magnified. On the right, without black background, is a single egg just before hatching.
,, 2. Nymphs, first instar, immediately after hatching and later.
,, 3. Nymph, second instar.
,, 4. ,, third ,,
,, 5. ,, fourth ,,
,, 6. ,, fifth ,,
,, 7. } Imago.
,, 8. }

The natural length of figures 2 to 8 is shown by the hair line beside each. (Reprinted from Memoirs of the Agricultural Department.)



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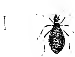

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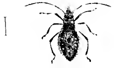

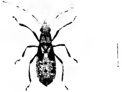

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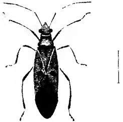

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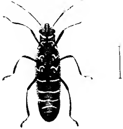

important, *Dysdercus cingulatus*, F., being a pest to cotton but no other species being as yet definitely known to be destructive. What checks there are on these insects remains to be seen; a Tachinid parasitises *Dysdercus cingulatus* and Mr. Mason has found that, despite the warning colouration and odour, birds eat this species.

Larginæ.—The female has the sixth ventral segment cleft at the base. *Lohita grandis*, Gray., is the most conspicuous of the sub-family. It is a large red and black species, the male with abnormally elongated abdomen and antennæ. Its appearance is striking and as it occasionally occurs abundantly on bhindi and cotton, it is sometimes taken to be a pest. Its distribution is, in India, confined to the warm moist areas of Bengal and Assam. *Iphita limbata*, Stal., is brownish red with pale edges to the wings and pronotum. It has been found in great numbers upon forest trees, large numbers living gregariously in depressions in the bark, the ground below littered with their exuviæ showing that they had lived in that situation for some period. Its distribution is also limited, but it will probably be found more widely spread in suitable places. *Physopelta gutta*, Burm., is not uncommon in Assam and Bengal, represented in the West of India by *P. apicalis*, Wlk. *P. schlanbuschi*, Fabr., will probably be found throughout the plains; it is common in Behar in the cold weather.

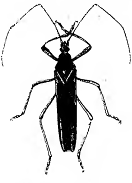
Fig. 458—LOHITA GRANDIS.

Pyrrhocorinæ.—*Antilochus coqueberti*, Fabr., is a common bug, bright scarlet with the membrane black, found in many localities among dense vegetation. *Odontopus nigricornis*, Stal., is similar but with a large black spot on each forewing. *Dermatinus lugubris*, Dist., is a small black insect with short truncate hemelytra, found widely in the plains. *Scantius pallens*, Dist., also appears to be common over Northern India on maize, bhindi and other crop plants; *S. volucris*, Gerst., appears to be common in the Central Provinces. *Dysdercus cingulatus*, Fabr. (Plate

LXXVII), is the most abundant species, feeding upon cotton, bhinda and many weeds and also in large number on the seeds of the silk-cotton (*Bombax malabaricum*). It will be readily mistaken for other species but is distinct in having white bands across the body beneath and a white collar. Its occurrence upon cotton and the destruction it causes to cotton are described elsewhere (Mem. Agric. Dept., India, Ent. Vol. II, No. 3). When the silk-cotton is in fruit, the bug multiplies enormously, and when the seed is blown down, the bug descends in great numbers and is found in masses on the ground. It is curiously gregarious, the vivid scarlet bugs assembling in bunches on their food-plant, a singularly pretty sight. *D. evanescens*, Dist., is conspicuous by the brown membrane of the hemelytra; it is widely spread in India but not abundant and only rarely captured.

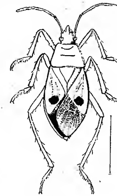

Fig. 459—Odontopus nigricornis.

Tingidæ.—*Lace-Wing Bugs.*

The hemelytra reticulate, the pronotum usually with reticulate markings extending on the lateral leaf-like expansions.

These small insects are amongst the most beautiful of the smaller insects, but are very little known and not generally noticed. Few have a length as great as one-quarter of an inch and all are dull-coloured and inconspicuous. The head is small and usually covered by the pronotum, which often has lateral expansions. The lace-like markings extend over the whole upper surface, the hemelytra being thin with irregular thick lines forming the ornamentation *Tingidæ*, so far as known, are purely plant-feeding insects, living as a rule gregariously upon their host plants. Their eggs, as far as known, are laid in plant tissues, the nymphs

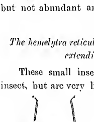

Fig. 460—Monanthia globulifera. (*From Distant.*)

feeding openly upon the leaves. None are pests and but little is known of this group. They are occasionally found abundantly and cases have been seen where they were so abundant upon a plant as to apparently cause damage. The small number of recorded Indian species is due to the minute size of the insects; only with a good lens can the nature of the little insect be discerned and they have on this account been but little collected. Distant has recently described more Indian species (Ann. Soc. Ent. Belge, 1909, p. 113).

Monanthia globulifera, Wlk., recorded from Madras and Ceylon, is found also in Behar upon an aromatic garden herb as also upon sweet Basil (*Ocimum basilicum*). *Urentius echinus*, Dist., is found, often abundantly, on brinjal (*Solanum melongena*). Green has observed that the nymphs live on the under, the imagines on the upper surface of the leaves. The leaves become discoloured, but there is no real damage done as a rule. E. J. Woodhouse has found *Paracopium cingalense* causing hypertrophy of the corolla of *Clerodendron phlomoides* in Bengal.

ARADIDÆ.

Flat, dull-coloured insects, the forelegs inserted on the disk of the sternum, without ocelli; tarsi two-jointed, antennæ four-jointed.

These bugs are of extremely distinct facies and easily recognised. The antennæ are short and thick; the body much flattened, the hemelytra lying flat upon the abdomen and only occupying the middle, the apex and sides of the abdomen visible from above. All are dull-coloured, black or brown, in conformity with their habitat, which is under bark, stones, fallen leaves, etc. Their habits appear to be wholly unknown and these insects are far from common. Nearly all the known Indian species are recorded from the hills; probably more will be found when the large soil-surface fauna comes to be investigated. *Neuroctenus par.*, Bergr., is the most likely species to be found, under conditions of sufficient moisture.

HEBRIDÆ.

Body clothed below with silvery pubescence. Antennæ five-jointed.

Small insects found in damp places and semi-aquatic in habit. A single species *Hebrus orientalis*, Dist., was collected in Burma by Fea, this being the only known species from British India. As the number of joints in the antenna is a matter authors do not agree on, the family is not easy to recognise.

HYDROMETRIDÆ.

Antennæ four-jointed. Body beneath clothed in silvery velvety pubescence. Live on surface of water.

These are small insects of dull colour, found on the surface of still water and on the sea. Grey, black, and dull straw colour are the prevailing tints. The antennæ are long, the eyes well developed, the rostrum short and curved. Nearly all are winged and fly readily: the legs are usually long and hairy, so that the insects can run along the surface film of water without "breaking" it.

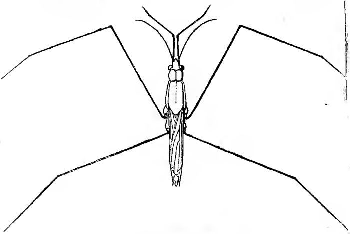

Fig. 461—GERRIS SPINOLÆ. × 5.

Nothing is on record as to their life-history in India; all are probably predaceous on insects which fall into the water. They have no economic importance and have been very little collected and not studied at all.

Mesoveliinæ.—*Mesovelia mulsanti*, Buch., is the sole species in India, a small insect found on water weeds in Indian rivers; it has escaped record, being known previously from Ceylon and from the Nearctic and Neotropical region.

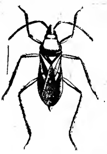

Fig. 462—MESOVELIA MULSANTI.

Hydrometrinæ—Hydrometra vittata, Stal., is the sole species of this sub-family found in India. The extremely linear form, the very elongate head with the eyes set in the middle and the antennæ at the apex make this a very striking insect. It is found on still water or on the mud at the sides of tanks and is a sluggish inactive insect. possibly predaceous.

Veliinæ.—Though the Palearctic *Velia currens*. Fabr., has been found in the extreme North of India, few other species appear to occur and few are likely to be found in the plains. *Microvelia singalensis*. Kby.. has been found to feed on larvæ of *Culex fatigans* in India (F. M. H.).

Gerrinæ.—At least five species of *Gerris* are known to occur in the plains of India. one or more of which are likely to be found in any slow moving or still fresh-water. These are elongate dark coloured insects with long posterior legs. the forelegs and antennæ of moderate length. the beak short, curved and formed as in the *Reduviidæ*. These insects move actively on the surface of water and are predaceous upon insects sucking out the juice of any which fall into the water or alight there. They are to some extent gregarious and in large tanks or lakes become very abundant. *G. fluviorum*, F., *G. fossarum*. F.. and *G. spinolæ*. Leth. et Sevn.. are common large forms: *G. nitida*. Mayr., and *G. tristan*. Kirk., represent the smaller forms.

Halobates are marine insects and while three are reported from the Indian Ocean. a fourth is found abundantly on the West Coast during May. when strong winds blow in from the sea and apparently bring in abundance of these insects. which are helpless on the sand. This is ***Halobates germanus***. Buch.. a pretty little grey insect. not hitherto recorded from this country. J. J. Walker has noted the occurrence of ***Halobates*** on the surface of the Indian Ocean at a distance of 500 miles from the nearest land (Ent. Mo. Mag. 1900, p. 115).

HENICOCEPHALIDÆ.

Head divided into two distinct lobes, prothorax into three. Hemelytra membranous.

This family includes small insects, allied to Reduviidæ, but with a very distinct facies. The figure exhibits the peculiarities of structure in our commonest form. There is but one genus *Henicocephalus*, with one species *H. basalis*, Westw., common in the plains. This has the tarsi single-jointed. the foretibia with two spurs at the apex. It is found in damp soil and is apparently a predaceous form not uncommon among decaying vegetation and in compost heaps where insect life is abundant.

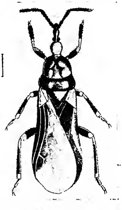
Fig. 463—HENICOCEPHALUS BASALIS.

PHYMATIDÆ.

The forelegs are short, the femur broadened, the tibia curved and pointed, tightly pressed against the femur.

These curious insects are recognisable from the peculiar forelegs, the tibia working against the femur as in Mantids or clawlike as in crabs. Of the 13 known Indian species, none are common, and all are hill forms, not likely to be found in the plains except after much searching. The insects are believed to be predaceous.

SALDIDÆ.

Rostrum curved, long. Ocelli placed between the eyes.

A small family with three recorded Indian species from widely separated localities. They may be recognised by the long curved rostrum, and by the absence of a cuneus in the elytron. *Salda Dixoni*, Dist., was found on the Bor Ghat (Bombay Presidency) and is the sole described truly Indian species. These insects as a rule live a semi-aquatic life in wet vegetation, or near water and more are likely to be found when they are looked for.

Valleriola cicindeloides, Dist. (A. N. H., 1909, p. 40), is found at Pusa running actively near an open water channel; it is extremely like a *Cicindela* in appearance and movements, and appears to be predaceous upon other insects.

REDUVIIDÆ.

Rostrum curved, usually stout, not closely pressed to the prosternum. Head usually elongate.

The strong curved beak is characteristic of the family and cannot be mistaken in the field. They are insects of moderate size from a quarter to over one inch in length, usually about half an inch. Colouring is either dull and sombre or vivid and warning, red and black being common in the latter case. A small number of species resemble the large brown Coreids, some resemble flies and Neuroptera, and others mimic brightly coloured Pyrrhocorids and Lygæids. The head is long, the eyes situate remote from the edge of the pronotum. The antennæ are simple and of moderate length. The rostrum is, with few exceptions, three-jointed. The prothorax is distinct and well developed, often transversely constricted in the middle. The wings lie flat on the abdomen in most species. The legs are long, formed for quick running; the femora and tibiæ are often spined. The form of the body is varied and while many are robust and similar to *Lygæidæ*, some are slender and resemble delicate flies. The sexes are usually similar, the female sometimes wingless when the male is winged.

Remarkably little is known of the details of the life-histories. Eggs are laid in clusters on plants or other objects in the open and are, in the known cases, of the cylindrical form found in Pentatomids with a lid that allows of emergence. The nymphs are similar in form and colouring to the adult, the wings developed during the later instars. Both nymphs and adults are found on plants, on grass, among herbage, under fallen leaves and in other situations in the open. A number are known to feed on the body fluids of insects, which they pierce with the beak and suck out, while the spined forelegs hold them. Some of these species have a painful bite, due to the injection of fluid at the moment of puncture. Others feed upon the juices of plants and somewhat divergent views are expressed as to the relative numbers which are predaceous and herbivorous. It is probably correct to say that of the common plains' species the majority are predaceous, a smaller number, especially those living on trees, herbivorous. Many are diurnal in habit, many nocturnal and the latter are attracted to light. As in other insects with no metamorphosis, the imaginal life is more extended and important than the nymphal. The duration of nymphal life is not known in detail: hibernation, æstivation and similar states are apparently passed mainly in the imaginal stage and no definite seasons for reproduction, etc., have been established. Like other insects they are most active and abundant during the rains, when both insect and plant life affords abundant food, but they are also to be found at other times, except when cold causes them to become dormant. None are recorded as pests and it is believed that most are beneficial. Nothing is known as to the enemies of these insects. Their powerful odour and, in some species, their poisonous bite are defensive and may protect them from birds and other foes. The species of *Acanthaspis*, *Conorhinus*, *Pirates* and *Ectrychotes* especially have a poisoned bite, one so painful that they should be handled by the student with care, lest in the surprise of the sudden pain the specimen escape.

Reduviidæ occur throughout the tropical and temperate zones, with the maximum development in moist tropical areas. The family is a large one and over 250 species are recorded as Indian by Distant in the Fauna of India. The greater number of these are recorded from the hills and the family does not seem to have been much collected in the plains.

The student requiring to identify species should consult the Fauna of India; the sub-families are a little complex, but are readily grasped if a reference collection is available or if a good number of specimens representing different sub-families can be compared; in the Harpactorinæ, the absence of any definite keys to the divisions makes the matter confusing but with patience the genus can be made out.

Holoptilinæ.—Membrane large, extending beyond the abdomen. Legs and antennæ with long hairs. *Holoptilus* is the only one of the two Indian genera likely to be found and none are common.

Emesinæ.—Anterior coxæ long, legs raptorial as in the Mantidæ. They are very slender insects, with long legs and some are apterous. One species, allied to *Myophanes*, has been found in the plains; the long legs, the long delicate wings and slender body give it an appearance like a Tipulid fly.

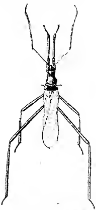

Fig. 464—Polytoxus maculatus, × 3

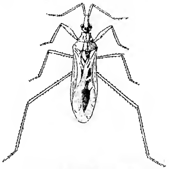

Fig. 465—Oncocephalus annulipes × 2.

Saicinæ.—Represented by *Polytoxus maculatus*, Dist., found rarely in the plains. This is a dry-grass coloured insect of slender build with one long spine at each side of the thorax.

Tribelocephalinæ.—*Tribelocephala indica*, Wlk., a dark brown species, is occasionally common at light. It is a flattened insect, about half an inch long.

Stenopodinæ.—*Sastrapada borensprungi*, Stal., an elongate insect of dry-grass colour, is rarely found in the plains of Assam. *Oncocephalus* is represented by *O. annulipes*, Stal., and other species, having the abdomen projecting beyond the sides of the hemelytra. They are of the same dry-grass colour and are found at light and on plants in the fields. *Salyavatinæ* comprise twelve species practically confined to the hills.

Acanthaspidinæ.—The pretty little *Reduvius cincticrus*, Reut., brown and yellow, represents this widespread genus in the plains. *Acanthaspis* is the large genus, with many species of whose distribution little is known. *A. quinquespinosa*, Fabr., *A. flavipes*, Stal., *A. rugulosa*, Stal., are widely spread and likely to be found. *A. rama*, Dist., and the small *A. coranodes*, Stal., are common in some localities

These insects are common on trees and under loose bark; they are nocturnal in habit and their bite is to be feared. All are warningly coloured, are protected by their odour, and probably by the stout spines on the thorax. The only other common insect is *Conorhinus rubrofasciatus*, de G., a common species found at light. The nymphs of this species are spiny and partially covered in debris which they gather; they are common in houses, living in dark dusty corners and probably preying upon the smaller forms of household insect life. Its American ally is the so-called "Kissing Bug."

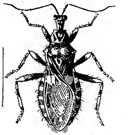
Fig. 466—ACANTHASPIS RAMA.

Piratinæ.—The elongate pronotum, constricted behind the middle, is a useful character in distinguishing this group. *Ectomocoris quadriguttatus*, Fabr., and *E. cordiger*, Stal., are the common species of this genus; they are nocturnal in habit, found in hiding by day and have an intensely painful bite. The large *Pirates* are readily confused differing only in the smaller tibial furrow; *P. sanctus*, Fabr., is a common form, as also is *P. lepturoides*, Wolff.

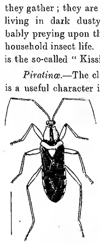
Fig. 467—PIRATES SANCTUS.

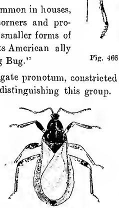
Fig. 468—ECTRYCHOTES DISPAR. × 3.

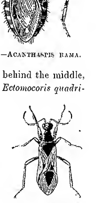
Fig. 469—PIRATES MUNDULUS. × 3.

Echtrichodiinæ.—The scutellum terminates in two broad apical points. *Ectrychotes dispar*, Reut., and *E. abbreviatus*, Reut., are moderate sized insects coloured in deep blue with some red markings, found under leaves, bark, etc. *Physorhynchus* and allied genera are remarkable in having the wings absent in the females or in both sexes; the female *P. marginatus*, Reut., attains a length of one and a half inches. None are common except in the hills.

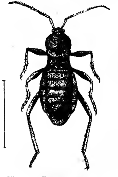

Fig. 470—PHYSORHYNCHUS MARGINATUS, FEMALE.

Apiomerinæ.—Four species not known in India.

Harpactorinæ.—Distinguished by the quadrangular areole at the base of the membrane. *Harpactor costalis*, Stal., is the commonest Reduviid seen in the fields by day, a red and black active insect that runs about among low vegetation. It is predaceous upon the Red Cotton Bug, *Dysdercus cingulatus*, which it resembles in colouring. *H. fuscipes*, Fabr., is also found but has not the yellowish stripes on the sides of the abdomen beneath. *H. marginatus*, Fabr., with the posterior half of the pronotum roughened, is common in the Central Provinces. *Sycanus versicolor*, Dohrn, is not uncommon, a striking red and black form with the sides of the abdomen dilated. *Cydnocoris crocatus*, Stal., is a more slender, yellow species, found in rice fields. *Isyndus obscurus*, Dall., though a hill form from Assam is worth note as it closely mimics the common Coreid *Elasmomia granulipes*, which occurs in the same localities. Two common forms are *Coranus spiniscutis*, Reut., and *C. obscurus*, Kby., small inconspicuous species found widely spread. They are typically members of the immense fauna

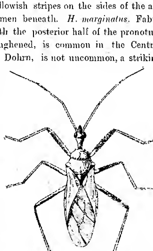

Fig. 471—HARPACTOR COSTALIS. × 3.

of the soil and probably prey on the small insects that abound there. *Scipinia horrida*, Stal., is a small dull insect, the head and prothorax spined above, found far more widely than is recorded. So also is *Irantha consobrina*, Dist., recorded only from the Nilgiris; these obscure Reduviids have been scarcely at all collected save in the hills and the plains fauna is obviously very little known.

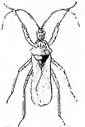
Fig. 472—SCIPINIA HORRIDA. × 3.

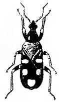
Fig. 473—PROSTEMMA FLAVOMACULATUM. × 3.

Nabidinæ.—The rostrum is four-jointed, not three-jointed. *Prostemma carduelis*, Dohrn., is the common representative of the robuster forms of this sub-family; *P. flavomaculatum*, Leth., is also found in grass among fallen leaves. *Nabis capsiformis*, Germ., is the very abundant green insect found in grass; it turns dull ochraceous when dry, while some are that colour in dead or dry grass. This abundant little insect has been observed sucking out caterpillars.

CERATOCOMBIDÆ.

Hemelytron with a cuneus and embolium; antennæ with the two apical joints long and slender, with long hairs.

A single specimen was found in Burma by Signor Fea, described as *Crescentius principatus*, Dist., in the Fauna of India. Distant writes of the group, "a family comprising some very small or minute species found in moss, dead leaves and similar surroundings."

CIMICIDÆ.—*Bed Bugs.*—

BY F. M. HOWLETT.

The body very flattened, the hemelytra and wings practically absent.

The general flattened appearance and dull reddish brown colour of Cimicidæ is familiar to most people. The rostrum is carried in a groove beneath the head (fig. 473), and the prothorax is well developed and sharply separated from the mesothorax, its hind margin being straight in *C. lectularius*, Linn., and rounded in *C. rotundatus*, Sign. (Fig. 474.)

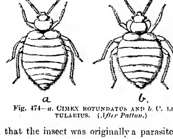

Fig. 474—*a.* Cimex rotundatus and *b.* C. lectularius. (*After Patton.*)

The notorious "bugs," insects far too abundant in houses in India, are the sole common representatives of this family. Their origin is obscure, and they were well-known to the Greeks and Romans; it is possible that the insect was originally a parasite of birds and mammals, and included man in its hosts: it is now not confined to man, but has other hosts. Its distribution is wide, as it is readily carried in steamers and can survive long periods, it may be even a year, without food. The eggs are laid in cracks in the floor, in the furniture, or in any convenient position to which the female can obtain access. They are beautifully shaped and sculptured, and the young escape by a round door at one end about five to ten days after they are laid. The young (fig. 476) are similar to the adult, but smaller, more transparent, and less darkly coloured. There are probably five moults, and if the insect is under favourable conditions where it can get blood easily, the whole life-history will probably occupy not more than two months. A meal of blood seems to be required before each moult and before egg-laying, and if it cannot be obtained the interval between the moults may be very greatly prolonged. When the insect wishes to suck blood, it injects liquid which is irritant and causes a flow of blood to the spot on which it gorges itself. Now that so much is becoming known

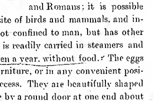

Fig. 475—Cimex head from below.

as to the part played in disseminating disease by biting insects, it is not unreasonable to suppose that this ubiquitous tormentor may be found to have a greater importance as a disease-carrier than it now has as a common household nuisance, and it has already appeared that the bite constitutes at least one way in which "kala-azar" is transmitted from man to man (Patton). It is nocturnal in habits as a rule but is active at all times, and the bite is irritant to most persons, though repeated inflictions appear to confer a certain degree of immunity. Travellers are aware of the ingenuity of the insect in reaching its prey and it has been observed that when all other means of access failed, it went to the ceiling and fell on its victim from that position. In America cockroaches and small red ants are mentioned by Marlatt (U. S. Ent., Circular No. 47), as being fond of eating bugs, the ants in particular being effective checks.

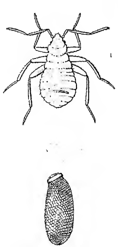
Fig. 476—Cimex lectularius, egg and nymph. × 16.

In some countries, fumigation with Hydrocyanic acid is utilised to free railway carriages and buildings from this pest. The use of superheated steam for this purpose might be given a trial in this country as being cheaper and less troublesome. Cleanliness, washing the floor and wooden bedsteads with Crude oil emulsion, the use of pure pyrethrum powder, and fumigation with sulphur or Hydrocyanic acid are the only means generally available against it. The leaves of *Pterospermum acerifolium* are used in India as a preventive of night attacks.

Two species attack man in India, *Cimex lectularius*, L., and *Cimex rotundatus*, Sign. (*C. microcephalus*, Dist.) (Patton, Indian Mus. Records).

ANTHOCORIDÆ.

***Hemelytra** with an embolium and a cuneus. Ocelli present; third and fourth joints of antennæ not twice as long as the first and second together.*

This family includes a small number of minute insects unlikely to be found by any but a collector of small Hemiptera only. Most are dark-coloured somewhat flattened insects resembling Capsidæ, with moderately long legs and antennæ. They are found in flowers where they appear to feed on pollen and Thrips. Distant enumerates ten species in the Fauna of India, none of which can be regarded as common insects so far as our present knowledge goes.

Triphleps tantilus, Motsch., is probably widely spread in the plains, a small black insect of less than one-tenth of an inch long, with some resemblance to *Oxycarænus*. It is found on sunflower and other green plants during the rains.

POLYCTENIDÆ.

One remarkable insect, recorded and described by Waterhouse from Secunderabad is the sole Indian representative of the family. This is *Polyctenes lyræ*, Waterh., a small insect found upon a bat on which presumably it is parasitic. The student will find an excellent figure in Distant's Fauna of India volume. It will readily be mistaken for a Nycteribiid, and is so regarded by some authors; it is elongate and flattened, with the head in two portions, the hemelytra much reduced, and the upper surface of the body with minute hairs. The three-jointed proboscis will distinguish it from other similar bat parasites. This and other bizarre forms of insect life will reward the collector who will systematically investigate the probably extensive fauna to be found on living bats.

CAPSIDÆ.

Hemelytron with a cuneus.

The above is the distinctive character of the family, combined with the absence of the embolium and of characters marking allied families. The species composing it are small delicate insects of dull colouring: the integument is less firmly chitinized than in other *Rhynchota*, the head is distinct, with four-jointed antennæ in which the basal joint is often dilated; ocelli are present in some species and eyes are well developed; the rostrum is four-jointed and more or less closely applied to the under surface of the body. The legs are moderately long and slender, the prothorax usually unarmed, and the known species are winged and fly readily. They bear a marked superficial resemblance to small beetles both in facies, colouring and attitudes, some leaping as the Halticides do.

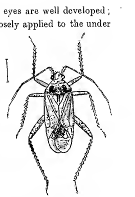
Fig. 477.—CALOCORIS LINEOLATUS. (*After Distant.*)

Little is known of their life-history; the female is provided with an ovipositor used for laying eggs in the tissues of plants. The life-history of one species, *Helopeltis theivora*, Waterh., is known in detail, and the student should consult the increasing literature of this insect in Ceylon and India. (Green, Dudgeon, Atkinson, Mann, Antram.) *Gallobellicus crassicornis*, Dist., has been observed to lay its eggs in the soft tissues of young shoots of tobacco. The eggs of *Disphinctus formosus*, Kirk., have been described by E. E. Green (Entomologist, 1901, p. 114). Each egg is laid singly in the shoots, and bears a short and a long divergent process which are exposed and not embedded. It is probable that all lay their eggs in the tissues of plants and that the number of moults will be the normal number, five; the full life-history of one at least in the plains deserves to be worked out. Equally little is known as to hibernation, and the insects are not common enough to render such observations easy.

Capsidæ are found on grass and low vegetation in greatest number and are, so far as known in India, wholly vegetarian (one species has been observed in the hills feeding on the excrement of birds). This is not the case elsewhere and it is probable that in India also predaceous species will be found. Besides the destructive mosquito blight of tea (*Helopeltis theivora*, Waterh.), several are destructive. *Calocoris* includes species which suck the soft grain of the big millet (*Andropogon sorghum*) in South India and elsewhere. *Disphinctus* includes the very destructive species, *D. politus*, Wlk., that attacks the betel vine (*Piper betel*) and one (*D. humeralis*, Wlk.), that attacks cinchona. Others are very likely to be found as pests.

The fauna includes 115 species and others have been added since (Entomologist, 1909, p. 58).

The family is divided into three sub-families :—

Mirinæ.—Head longitudinally grooved or anteriorly excavated.

Capsinæ.—Head not grooved. Ocelli absent.

Isometopinæ.—Head not grooved. Ocelli present.

Mirinæ.—A small dull greenish form found abundantly in grass, occurs in the plains, *Megalocerœa dohertyi*, Dist. A commoner insect is *Megacœlum stramineum*, Wlk., a dry-grass-coloured insect found abundantly on crops and low vegetation. This or other species of the genus will probably be found everywhere in the plains in the rains, and it is probable that they are to some extent destructive. *Helopeltis* is strictly a hill genus, but R. M. Dixon states that *H. antonii*, Sign., feeds on *Cucurbitaceœ* in Bombay.

Capsinæ.—*Disphinctus* is placed in this sub-family and includes five hill species, all recorded as to some extent injuring plants. *Disphinctus politus*, Wlk., is responsible for serious damage to betel vine in Kanara and Bassein (Thana), puncturing the leaves which decay and are then worthless. *Calocoris angustatus*, Leth., was described from specimens found attacking cholum (*Andropogon sorghum*) in South India : this or allied species are responsible for wide destruction in some seasons. *Pœciloscytus longicornis*, Reut., is a tiny black species found on vegetation and probably widespread if looked for. *Gallobelicus crassicornis*

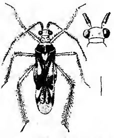

Fig. 478.—DISPHINCTUS HUMERALIS. (*After Distant.*)

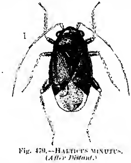

Fig. 479.—HALTICUS MINUTUS. (*After Distant.*)

Dist., is a small narrow dry-grass species (green when alive), which sometimes occurs in great numbers on weeds or cultivated plants. R. M. Dixon found it a garden pest in Bombay, and in Pusa it has been found infesting tobacco and breeding on it. *Halticus minutus*. Reut., is apparently so-called from the resemblance to a Halticid beetle ; it is a small dark shining-black bug, which has been observed by E. E. Green to leap like a flea beetle, thus completing the resemblance. It has been found in the plains of India.

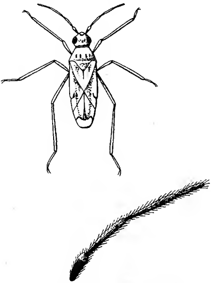

Fig. 480—GALLOBELLICUS CRASSICORNIS ; ANTENNA BELOW. (I. M. N.)

Isometopinæ.—" They are minute insects and require special search and collecting." This is Distant's remark ; he lists 7 species from Ceylon and Burmah.

CRYPTOCERATA.

This division includes the truly aquatic forms, as distinct from the land forms and those living on the surface of water. Apart from the mere enumeration of species, practically nothing has been done to investigate these insects, and there is a very large field open to an investigator in almost any part of the plains. They have probably no economic importance whatever, and the study of these insects even in Europe and the United States is very little advanced.

PELOGONIDÆ.—(*Galgulidæ*).

Body short and broad ; head very broad with prominent eyes ; ocelli present. Posterior legs thin, formed for running.

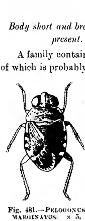

Fig. 481.—PELOGONUS MARGINATUS × 5.

A family containing but four recorded species in India, one at least of which is probably very widely spread over the plains. These insects are of small to moderate size, the body broad and flat, the head broad with prominent eyes, the posterior legs not formed for swimming, but for running or leaping. *Pelogonus marginatus*, Latr., has been found on the mud on the banks of streams ; it is an active little insect of a dull colour, with small ochreous spots : when approached it leaps vigorously, alighting some distance off and lying flat on the mud. It is most readily captured by being chased to the water when it leaps in, and is for the moment helpless. *Mononyx* includes rather larger insects of a rather brownish colour and roughened above ; the forelegs are raptorial, the femur dilated, the tarsus single jointed. Three species are recorded from Burmah, Sikhim and Assam ; more remain to be captured probably. Nothing appears to be on record as to the habits of these insects ; *Mononyx indicus*, Atk., is not uncommon in Assam and Sikhim, where it is found on grass paths, on the soil and under stones, as well as on hard roads : it is not aquatic and is possibly predaceous on small insects.

Pelogonus marginatus, Latr., has been observed to suck a helpless insect on the surface of the stream near the margin and the structure of the legs of *Mononyx* would indicate that it has somewhat similar habits.

NEPIDÆ.

Abdomen with a long (retractile) process; antennæ three-jointed; fore-legs inserted on disk of anterior margin of prosternum.

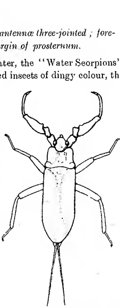

Fig. 482.—LACCOTREPHES MACULATUS. × 2.

Among insects found in shallow fresh water, the "Water Scorpions" are at once recognisable. They are flattened insects of dingy colour, the body elongate with nearly parallel sides; the anterior legs are very conspicuous, being raptorial in something the same way as those of a mantis. The antennæ are short and concealed; the rostrum is short and powerful; the eyes are well developed; the hemelytra cover the body and wings, and there are two long apical filaments which serve as a tube for conducting air under the hemelytra and so to the spiracles. These insects are found in water, which they rarely leave until migration to a fresh locality becomes necessary. They are believed to be wholly predaceous on other aquatic insects. None are known to have been reared in India, and but little is known of their habits anywhere. Eggs are said to be laid in aquatic plants and floating stems, and are provided with a number of filaments at one end (2 in *Ranatra*, 7 in *Nepa*), to facilitate respiration.

The eggs of a species of *Laccotrephes* have been found in the leaf of *Nelumbium speciosum*; they are about 2 m.m. long, cylindrical, with one end rounded, the other end truncate; the rim of the truncate end bears long straight spines, set radially at right angles to the long axis of the egg; there are 14 in some eggs, 15 in others. The spines measure nearly 2 m.m. in length. These eggs are placed through the leaf, so that only the spines and flat end appear above, while the egg projects below into the water; the spines hold the egg, lying flat on the upper surface of the leaf. On hatching, the egg breaks from the disc and spines, and the nymph emerges through the wide opening into the water direct. The young nymph has a process at the hind end, which projects beyond the abdomen, and the tip of which constantly rests on the surface of the

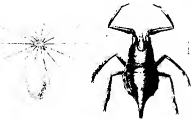

Fig. 183.—Laccotrephes sp. egg, × 10, nymph.

water: this process consists of two incomplete tubes, open below along their line of junction, and leading to the ventral surface of the abdomen: air is contained and held in them and passes along the body below, on each side, so that air is in connection with the spiracles and the atmosphere above the water. The nymphs were fed on fly maggots which they held in the forelegs and sucked out. All died at or before the last moult: the length of the syphon increased at each moult, and the wing lobes appeared at the second moult, there being five in all.

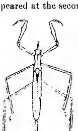

Fig. 184.—Ranatra filiformis.

Distant records three genera and eleven species as Indian, but this number may be expected to be increased. *Laccotrephes* is the Indian form of *Nepa*, the broader flatter insect in which the coxæ are short, the tibia and tarsus working against the grooved femur. There are three species: *L. robustus*, Stal., the largest, in which the abdomen above is sanguineous; *L. ruber*, Linn., smaller, the abdomen above reddish orange; and *L. maculatus*, Fabr., the smallest, in which the abdomen above is dusky. The two last are common throughout the plains.

Ranatra and *Cercotmetus* are both very narrow, the coxæ much developed and long; *Ranatra* alone is common in the plains with six species, two of which are widespread in India. *R. elongata*, Fabr., is the larger (44 m.m.), a dull grey-brown insect with long respiratory filaments; *R. filiformis*, Fabr., is browner and smaller (26 m.m.). It is likely that the smallest species. *R. sordidula*, Dohrn., will also be found as it is known from Calcutta.

NAUCORIDÆ.

Posterior tibiæ spinulose. Antennæ four-jointed. Forelegs inserted on disk of anterior margin of prosternum.

A small family of insects of which practically nothing is known in India. They are readily distinguished by the characters given, are of moderate to small size and of dull colour. The head is more or less deeply sunk in the thorax, the antennæ are concealed, the eyes well developed. The forelegs are raptorial, the poster or legs formed for swimming. All are flattened, oval in outline, compactly built and evidently swimming insects. The hemelytra cover the wings and body, and act as air-holders.

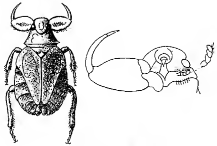

Fig. 485 CHEIROCHELA ASSAMENSIS, ON RIGHT, HEAD FROM BELOW. (*From Hope.*)

Nothing is on record as to their habits and life-history. Distant describes six genera and fourteen species divided among three sub-families. Judging from the recorded distribution of these species and the paucity of specimens in collections, we may for the present conclude that none are common in the plains or likely to be found there until some are actually found in more than one locality. We figure the delightful little *Cheirochela assamensis*, Ho., known from two localities in Assam and Burmah. *Gestroiella*. *Diaphorocoris*, *Heleocoris*, *Ctenipocoris* and *Thurselinus* are the remaining genera.

BELOSTOMIDÆ.

Posterior tibiæ flattened, with swimming hairs. Antennæ of four joints ; forelegs inserted in the disk of anterior margin of prosternum.

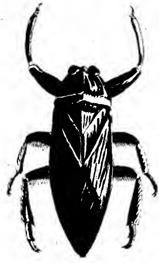
Fig. 486—BELOSTOMA INDICA.

This family includes the largest bug known. the flat brown *Belostoma* (fig. 486), which comes to the search-lights on the Assam river steamers and is probably familiar to all who travel there. It also includes species of more moderate size. All are flattened, formed for swimming, with predaceous forelegs and swimming hind legs : there are short abdominal appendages to conduct the air to a band of pubescence passing laterally round the lower surface of the abdomen. The head is a little produced in front and bears a short powerful beak. Little is known of their transformations or habits ; for long it has been known that in some forms the eggs were carried on the back : they are fastened to the hemelytra as shown in figures. In one American species the male is stated to carry the eggs. That this is the case also with *Sphærodema molestum*. Duf., we have proved by dissection of egg-bearing individuals. In the case of this species also the young have been observed to hatch from the eggs and live in captivity : they are similar in shape to the parent and the spiracles are on the edge of a band of pubescence which passes along the ventral side of the abdomen and holds air : this divided pubescent band passes to the hind end of the body, where are two pubescent processes and the little insect hangs obliquely at the surface when it wants air. The young were predaceous on small insects and all of the family are probably predaceous at all stages.

Three genera are recorded as Indian. *Nectocoris* contains one *N. stolii*, Mayr., from Burma. *Sphærodema* contains three, *S. annulatum*, Fabr., which is broad, *S. rusticum*, Fabr., narrower with short anterior claws and *S. molestum*, Duf., which is narrow but with longer tarsal claws in front. The first of these appears to be the most common.

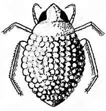

Fig. 487.—SPHÆRODEMA MOLESTUM, MALE, CARRYING EGGS. × 2.

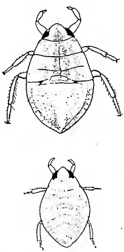

Fig. 488.—SPHÆRODEMA MOLESTUM. NYMPH, FIRST AND SECOND INSTARS. × 5.

Belostoma is the only genus of large insects, with but two recorded Indian species. It is found at light and requires to be handled with very great care as its puncture is poisoned and painful. *B. indicum*, Lep. et Serv., is the common species, the second (*B. Deyrollei*; Vuill.,) being known only from the Brahmaputra.

Mr. Herbert Manners has observed that *B. indica* feeds upon the common Indian toad (*Bufo melanostictus*); it grips the young toads that are on the surface of ponds and grasping them tightly, works round underneath, till the beak can be inserted between the toad's hind legs, the apex of the abdomen of the bug being towards the toad's head. The toad appears to be unable to struggle and becomes flabby. He also observed that small fish are eaten. E. E. Green in Ceylon observed the eggs to be laid under water in an aquarium (Entomologist, 1901, p. 113). The eggs of this species are laid in clusters on the stems of plants growing at the edge of water, so that the emerging nymphs can fall into mud. They are large pear-shaped eggs, the mass forming a very conspicuous object.

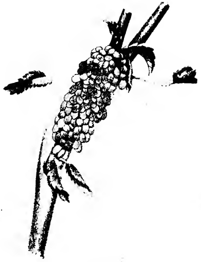

Fig. 489.—EGGS OF BELOSTOMA INDICA. × 1.

NOTONECTIDÆ.

Forelegs inserted on posterior margin of prosternum. Rostrum free, three to four jointed.

This family is very closely allied to the next and with it at once distinguishable from all others when seen in the water. The point of difference is that these swim "upside down," *i.e.*, on their backs while *Corixidæ* swim in the reverse manner. The body is convex and not flattened; the eyes are large, the head sunk in the thorax, the body formed for swimming. The beak is short and stout; the forelegs are formed for grasping, the posterior legs for swimming. Air is taken under the elytra and these insects come to the surface periodically. Nothing appears to be known as to the habits of Indian species; they are probably predaceous and some are sufficiently common in freshwater tanks. The eggs are said to be inserted into the stems of plants.

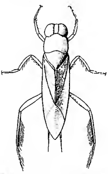

Fig. 490—Enithares templetoni. × 5.

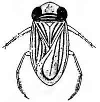

Fig. 491—Micronecta striata. × 6.

Distant mentions fourteen species in the following genera: *Notonecta* (2), *Enithares* (5), *Anisops* (3), *Plea* (4). The actual distribution in India of these insects appears to be unknown.

CORIXIDÆ.

Forelegs inserted on the posterior margin of the prosternum. Rostrum concealed, apparently unjointed.

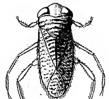

Fig. 492—Corixa hieroglyphica. × 5.

Like the last but flattened, the scutellum small, the forelegs short. There are but three recorded species from India, of whose life-history and habits very little is known. *Corixa hieroglyphica*, Duf., is probably widespread and occurs also over Northern Asia, Europe and America. It is abundant in tanks in the plains, swimming actively and periodically returning to the surface for its air supply. *Micronecta* (Sigara), *striata*, Freb., is also probably common, while one other species is recorded from Ceylon.

HOMOPTERA.

The front of the head is bent so as to be in contact with the fore coxæ. The tegmina are of one consistence throughout and lie over the abdomen at an angle.

While there is little doubt that from the field naturalist's point of view there should be at least nine families in this sub-order, on structural

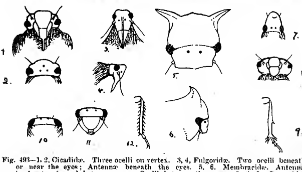

Fig. 493—1, 2, Cicadidæ. Three ocelli on vertex. 3, 4, Fulgoridæ. Two ocelli beneath or near the eyes; Antennæ beneath the eyes. 5, 6. Membracidæ. Antennæ in front of and between eyes; Ocelli between the eyes. 7, 8, 9. Cercopidæ. Ocelli on vertex. Cluster of spinules at apex of tibia. 10, 11, 12. Jassid. Ocelli in line with front of eyes; Double row of spines beneath posterior tibiæ.

grounds authorities are not agreed as to the number of families. We would divide the sub-order into two, keeping the old division *Phytophthires* for the last four families which are so sharply distinct in habits.

Homoptera.	*Cicadidæ.*	Three ocelli on vertex.
	Fulgoridæ.	Ocelli two, placed beneath or very near the eyes, not on the vertex. Antennæ beneath the eyes.
	Membracidæ.	Ocelli two, between the eyes. Antennæ in front of eyes. Prothorax prolonged backwards.
	Cercopidæ.	Ocelli two, on vertex. Hind tibiæ with stout teeth, and with short spines at the tip.
	Jassidæ.	Ocelli two, on front margin or frons. Hind tibiæ with a double row of spines.

Phytophthires	*Psyllidæ.*	The wings at an angle over the body, two pairs. Three ocelli. long thin antennæ.
	Aphidæ	Siphons usually present. Often wingless. Wings held erect, hyaline.
	Aleurodidæ.	Wings four, mealy, opaque.
	Coccidæ.	Female wingless, male usually winged with one pair of wings only.

CICADIDÆ.

Three ocelli in a triangle on the vertex. Tarsi with three-joints. Male with a musical apparatus.

The Cicadas are the largest insects of the *Homoptera*, with an expanse of one to several inches. They are readily recognised by the ocelli if not at once from the general form. The head is well developed, with short antennæ consisting of a bristle set on a basal joint. The wings are large, often coloured and lie at an angle over the abdomen. The eyes are well developed, as is the beak which lies under the head; the thorax is well developed, the mesonotum large and conspicuous. The abdomen is broadly joined to the thorax; the female has a distinct ovipositor; the male has the base of the abdomen modified to form sound producing organs, with more or less distinct external flaps which are valuable for the discrimination of species. The legs offer no peculiarities and are formed for clinging while the empodium is absent.

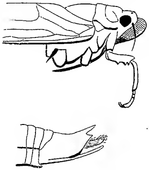

Fig. 494.—COSMOPSALTRIA SATURATA. Thorax and head above; apex of abdomen of female below.

Very little is known as to the life-history of Indian species. The eggs of some foreign species are known to be laid in bark. The nymphs have been found at the roots of plants and in termites' nests, but nothing is known of their habits in India. When full grown, the nymphs come up from the ground, fix themselves on a plant, and the adult emerges. These empty skins are a common feature in the hills. (Fig. 495). The length of the life-history is unknown, though one American species is known to live seventeen years, the imago only appearing for one summer, the nymphs living for sixteen years.

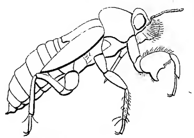

Fig. 495.—COSMOPSALTRIA SATURATA. NYMPH.

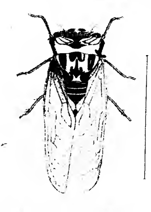

Fig 496.—PLATYPLEURA MACKINNONI.

Cicadas are dependent upon trees for food, so far as is known, and occur most abundantly in forests and well-wooded moist localities. The imagos certainly suck the sap of trees and are so coloured as to be exceedingly difficult to see when on tree bark. They are known best for the extremely shrill sustained sounds produced by the males, a sound which has no rival except in the steam whistle. After a shower the noise is deafening if one is in a forest with many Cicadas and the kind of noise produced varies immensely with the different species. The sound appears to come from all round and is, unless one has much practice, extremely difficult to locate. The sound is produced by the vibration of a tense membrane situated in the base of the thorax ; there is a muscle attached to it which is supposed to produce vibrations, which are believed to be magnified by other membranes and by the operculum. A conspicuous feature of the process is the vibration of the abdomen which produces the trill, as apart from the vibration of the membrane producing the usual shrill high note. We confess to being unable to follow the descriptions of the mechanism as given by authors and it is not quite clear how the volume of sound is produced. The object of the sound is a mystery though, as it occurs only in the males ; it may be sexual or simply a diversion for the males which have no egg-laying to do.

Cicadas are rare in the plains and but few species occur there ; they are characteristic of moist subtropical India : it is unnecessary, therefore, to discuss the classification in detail. Distant's volume III of Rhynchota in the Fauna of India enumerates 148 species as Indian, divided into three sub-families. The only species apparently really common outside hill localities is *Platypleura octoguttata*, Fabr., found in the hills and in the plains. *P. mackinnoni*, Dist., is found in Behar.

SONG IN INSECTS.

A large proportion of the sounds heard in the field are produced by insects and, while the motive that induces sound production is not always known, it is probably connected with sex, with simple forms of signalling and alarm giving, with protection from enemies, and finally with the simple expression of the emotions. The majority of the sounds heard are connected with sex, but it is by no means clear to what motive to attribute the loud continuous song of the Cicada, the most prominent of all insect noises.

Sound is produced in insects almost always by the friction of one hard part of the integument against another. When one considers the hardness and beautiful jointing of the segments, the complexity and position of the limbs and wings, it is easy to realise that no very great structural modifications are required to enable one plate to rub against another in such a way as to produce rhythmical vibration. In a few species, sound is produced in other ways, by modifications of the spiracles so that the movement of the contained air may cause vibration, by mechanism connected with the wings and their vibration or by special musical organs with specially adapted muscles. We cannot in this place deal exhaustively with such a subject nor even discuss the extremely interesting Indian songsters more than extremely briefly: the curious reader will find fuller details in the papers mentioned.

Acridiidæ do make sounds but, in our experience, only rarely. We have never heard the migratory locust make a sound, and after prolonged observation we learnt that only when in the act of mating does the Bombay locust emit a feeble chirp, produced in the usual manner by rubbing the hind femur against the tegmen. It is rare that *Acridiidæ* make sounds in any other way. (See *Aularches*.) Far more noisy in India are the *Locustidæ*, some species of which keep up a shrill noise in grass while others make noises of various kinds in trees. In the *Locustidæ*, the male has the base of the tegmina flattened, that of the upper (right one) with a sharp point which works on a file on the lower (left); as the wings are moved, the vibration is set up, its pitch and intensity determined by the length and tension of the tegmen, and so a note produced. *Conocephalus indicus* is probably the species most commonly heard, its shrill note in the grass always appearing to be a little distance off but never in any one definite direction. *Gryllidæ* are often troublesome from the shrillness and persistency of their song: the sound is produced by the vibration of the forewings on the hind wings and one can see the wings and tegmina in a state of vibration when the insect is engaged in song. The large *Brachytrypes achatinus* makes a sound which is extremely powerful and, when close, almost unbearable. It is the loudest songster in the plains where Cicadas are scarce.

Dragon flies are said to produce sounds by a process in the large trachea being thrown into vibration by the passage of the air, but we are not aware that this has been noted in Indian species.

Among Hymenoptera, *Mutilla* squeaks by the friction of the abdominal segments, *Lobopelta*, *Sima* and other ants by friction of the peduncle and basal abdominal segments, and bees (by the vibration of the wing if this can be called a sound and) by mechanism connected with the respiratory system, whereby the hum heard in a bee-hive is said to be produced.

In beetles, sound-production occurs in both sexes, as well as in some larvæ, and there are excellent accounts of the mechanism in different beetles. *Anobium* is said to tap with its head: the friction of the jaws of some longicorn larvæ in dry wood is quite audible in some cases. Gahan describes stridulating organs in almost every part of the body in beetles: perhaps the most familiar instances are those large Cerambycid beetles (such as *Batocera rubra*) in which the hind edge of the pronotum rubs on a file on the mesonotum. The reader should consult Gahan's article (Trans. Ent. Soc. Lond. 1900, p. 433) and Arrow's article on "Sound Production in the Lamellicorn Beetles." (Trans. Ent. Soc. Lond. 1904, p. 709.) It is worth noting that in Coleoptera, the stridulating organs commonly occur in both sexes and not, as in some groups, in the males alone. Among moths, our common death's head (*Acherontia styx*, Westw.) produces a sound by the friction of the palpi and the proboscis. This is stated to occur also in other species. A Sphingid larva common in the hills also produces a hissing sound on being touched; this is probably protective, just as the bizarre spots on these larvæ are.

Shipley and Wilson have described a sound-producing organ which is found on the wing of the mosquito *Anopheles maculipennis*, Meig. At the base of the wing is a movable bar bearing teeth, which engage against ridges on another slightly movable bar; the vibration of the wing produces movement of the teeth against the ridges, causing rapid vibration; the note is ordinarily constant in pitch but rises as the wing is shortened. (Trans. Roy. Soc. Edin. XL, pt. II, No. 13, 1902.)

Lowne states that the common blowfly, as some other Diptera, emits sound through the large thoracic spiracles. Amongst Hemiptera, besides the stridulation of *Tessaratoma papillosa*, Thunb., we find that certain *Reduviids* can emit sounds; *Corixa* emits musical chirps, produced by the friction of the forelegs on the beak.

Finally the Cicadas are notorious for their voices, the males singing constantly. Their song is produced by a tense membrane to which is attached a muscle, which throws the membrane into vibration; the vibrations are intensified by other resonant membranes and by the leaf-like lobes on the ventral surface. It is said that the peculiar diminution and intensification of the sound heard in some South Indian species (and which is exactly like that of the watchman's wooden rattle used at the boatraces at Cambridge) is produced by the opening and closing of the aperture at the base of the abdomen.

Finally we may remark that it is probable that many insects produce sounds unheard by us, since our ear will not record vibrations of more than a definite rapidity. Observations on a number of insects have shown that in some cases there are auditory organs in species whose song has not been heard, and that in others the movement necessary to produce song can be perceived but no sound is heard. This is the case with one of our common crickets; we have frequently seen its wings in vibration in a similar manner to that of *Brachytrypes achatinus*, but we can only hear the sound produced by the latter. It is possible that investigation of the anatomy of insects will reveal auditory and sound-producing apparatus in a greater number than are at present known.

FULGORIDÆ.

Ocelli usually two, placed in cavities beneath the eyes: antennæ of two joints and a bristle, placed beneath the eyes.

This is the largest, if not the most important, family of *Homoptera* occurring in the plains and it includes a considerable variety of forms. A number are large brightly coloured moth-like forms which fly by day and are warningly or cryptically coloured; a large number more are small dull coloured insects found in grass and forming an important part of the fauna of pasture; while a small number of insufficiently known forms live on the roots of grasses or other plants, in the soil. The structure is immensely varied and in few other groups is such a variety of forms equalled. The head is distinct, often prolonged upwards and forwards into grotesque shapes, produced below and ending in the rostrum with sucking mouthparts. Eyes are often large, the small ocelli set in cavities near them. Antennæ consist usually of two joints and a bristle, but these joints are often long and flattened, and are furnished with peculiar sensory organs. The body is well developed and short, with tegmina and, as a rule, wings; the tegmina are thickened and coloured or hyaline, and in repose are carried over the abdomen, meeting in the middle and sloped at varying angles. Wings are sometimes minute, often ample but rarely coloured or ornamented. The legs share in the general bizarreness of form, the forelegs sometimes foliaceously expanded, the hind legs with a tuft of spurs and a varied number of spines. The females are similar to the males except in the external genital organs.

Very little is known of the life-history. Eggs are commonly laid in the tissues of plants (in a cut made by the female ovipositor) or on them and are often covered in a white mealy secretion produced by the female, a mass of which is usually found on her abdomen. The number of moults is unknown except in *Pyrilla* (Zamila) *aberrans* where it is five. The nymphs are often clothed in wax similar to that of the females and some are very active leaping insects. Known species occur most abundantly when food is plentiful in the rains and they are known to hibernate in shelter in any stage, the cold, simply checking development. Two species are known to be pests to crops, and the importance of the family as a whole cannot as yet be settled. A study of the parasites of this family would yield results of interest and we are almost wholly ignorant as to the checks on their increase beyond those caused

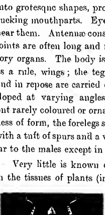

Fig. 497—Pyrilla aberrans. Last Nymphal Instar. × 4.

by egg parasites and lack of food. The work of Perkins in Hawaii has shown that one species at least is attacked by a variety of parasites and one of the Indian species is also the host of several parasites. (See *Dryinidæ*, page 170.) These parasites presumably check the increase of these insects and some Fossorial wasps store their nests with Fulgorids, which is another check upon their increase.

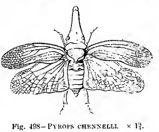

Fig. 498—PYROPS CHENNELLI. × 1¾.

The classification of *Fulgoridæ* cannot yet be said to have arrived near to definiteness from the extremely little really known of this large family. Distant, following Stal, makes twelve sub-families, the key to which is in the volume of the Fauna. We are not in a position to enter into this here, so small a portion of our plains species having been worked out and the student of this family should consult the original volume which we follow. We may remark that we hope that a revision of the family, and its division into more natural groups will follow from increased knowledge of tropical forms, little known as yet. It is unfortunate that only the smaller and less known species occur in the plains and that these have been so little studied. The giants of the family are wholly hill insects and must be omitted here. Records are extremely scanty in this family so far as plains species are concerned and of the 330 species mentioned by Distant, barely a dozen are mentioned by him as common in the plains or as occurring in localities at low elevations. This is due, not to the small number of plains species, so much as to the fact that collectors have gone to the hills and no collections have been made in the plains. We are dependent upon the Pusa collections in this case and the species mentioned are those we have found.

Fulgorinæ.—Anal area of wings reticulate, ridge separating frons and gena continued on to clypeus. This sub-family includes the large, beautifully coloured hill forms in which the prolongation of the head takes such curious forms. (Fig. 498.) Unfortunately only one (*Pyrops chennelli*) appears to be a common plains form and the recorded species are wholly forest and jungle hill species.

Eurybrachydinæ.—Anterior legs compressed, dilated; face broad, angled at each side. The broad flat face ending in an angled prominence at each side marks these insects. *Eurybrachys* is common, *E. tomentosa*, F., especially, which has broad olive-green tegmina mottled with yellow, a green head or pronotum and mesonotum, and purple-red metanotum, sternum and legs: the female has a mass of white mealy wax on the abdomen and is found on bhinda (*Hibiscus esculentus*) and other Malvaceous plants. Large numbers of eggs are deposited in this wax on the plant, hatching to small active bugs which suck the plant. The insect is a very striking one; *E. apicalis*, Wlk., in which the wings are fuscous (in *E. tomentosa*, they are white), is also found and apparently has similar habits.

Dictyopharinæ.—No apical ocellus. Sides of clypeus carinate or acute. Chiefly characterised by the absence of characters used for other sub-families. *Dichoptera* includes one common plains form, *D. hyalinata*, F., which suggests a Cicada. It is one of the largest forms in the plains with an expanse of two inches and the tegmina hyaline with a single transverse fascia. It is found feeding upon the wild fig trees, the pipal, banyan, gular, etc. *Dictyophara* is a large and widespread genus, with at least three common species likely to be found. The head is usually produced forwards and upwards, the tegmina are long and narrow, the hind tibia with four to six spines; our species are small and delicate, with a body length of about ¼ to ⅓ inch. *D. sauropsis*, Wlk., has a short head, and is green in colour; *D. walkeri*, Atk., is smaller, pale ochraceous in dry specimens but green in fresh ones; *D. lineata*, Don., has two longitudinal fuscous fasciæ in the tegmina. All are common in grass and can be found readily. The last is perhaps the most common but this probably varies with the locality. *Udugama splendens*, Germ., is a little larger, ochreous (green) in colour, the tegmina with a fuscous stigma and apex; the head is only slightly produced.

Cixiinæ.—Three ocelli, one on the apex of the frons; claval vein not reaching the apex of the tegmen. *Oliarus* is represented by several species, small dark insects with rather long hyaline wings, the mesonotum with five distinct ridges. So far as known, these small insects live in grass and at the roots of plants. *Brixia*, in which the face is long, narrow, with strongly carinate lateral margins, has one species recorded from Bombay, which is likely to be found elsewhere.

Tropiduchinæ.—Margin of clypeus not carinate; basal joint of posterior tarsus long. A small number of species, largely from Ceylon, are recorded; none are yet known to occur in the plains of India.

Achilinæ.—Clypeal margin carinate. Eleven species, chiefly of Ceylon forms are included herein.

Derbiinæ.—Vertex and face of head narrow; apical joint of rostrum short. One of the commonest small Fulgorids is included herein, *Phenice moesta*, Westw., found commonly on cane, grasses and cereals in the plains. The imago sits on the lower surface of the leaves, sucking the juice, the long narrow tegmina standing straight out at right angles to the body. *Drona* is not uncommonly represented by a reddish form, apparently not recorded as Indian, in which the tegmina are long and hyaline, the wings very small. *Nisia atrovenosa*, Leth., is probably also common as we have it from the plains, a small ochreous insect in which the wings are of more normal size.

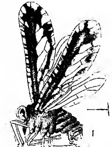

Fig 499—PHENICE MOESTA. (I. M. N.)

Lophopinæ.—Basal joint of posterior tarsi robust, short. *Elasmoscelis platypoda*, Kby., will be found, a small dark insect, with deepbrown tegmina and the anterior tibiæ flattened and dilated. *Brixioides carinatus*, Kby., is also found in the plains, a small ochraceous insect in which the face is dilated in front in two ridges which are noticeably striped.

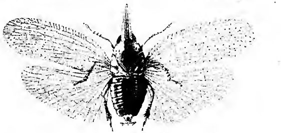

Fig. 500—PYRILLA ABERRANS. × 5. (I. M. N.)

Pyrilla (Zamila) *aberrans*, Wlk. (*lycoides*, Wlk.), has been confused with *Dictyophara pallida*, Don., in Indian Museum Notes and other publications. It is an important pest to cane, the bug sucking the juice of the leaves and seriously affecting the sugar-content of the plant. The full life-history is described elsewhere and we figure two stages. This insect is found practically throughout India.

Issinæ.—These are small forms with thickened tegmina; our common form (*Caliscelis eximia*, Stal.) is wingless with abbreviated tegmina, the long forelegs flattened and much dilated. The female is dull ochreous, the male ochreous and piceous. It is a common enough insect in grass, but its small size makes it inconspicuous. *Hilda bengalensis*, Dist. (A. N. H., 1909, p. 40), is a small brightly-coloured species found upon the pods and shoots of Amaltas (*Cassia fistula*) and pipal (*Ficus religiosus*) in Behar. Its oval eggs are laid in clusters on the bark. The young are gregarious, often found with the adults, and remain quiescent upon the food-plant. Ants visit them frequently and in some instances the red ant has been found to enclose and care for them.

Ricaniinæ.—Our species have large ample tegmina and wings, the former more or less darkened. *Ricania* includes one common species, *R. zebra*, Dist., in which the deep brown tegmina have transverse lighter stripes and lines. This is a common insect in grass and in rice, where it sucks the juice of the green plants. *Ricania apicalis*, Wlk., and *R. simulans*, Wlk., also occur more rarely.

Flatinæ.—Clavus granulate. The costa often much dilated, with many cross veins. This sub-family includes the beautiful moth-like

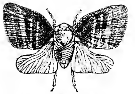

Fig. 501—RICANIA ZEBRA. × 3.

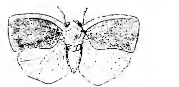

Fig. 502—MELICHARA LUTESCENS. × 2.

species, with ample tegmina lying at an angle over the body which are so striking when first seen. *Lawana conspersa*, Wlk., is a large creamy white species found breeding in the plains. *Phromnia marginella*, Oliv., is not a plains insect but is sufficiently striking to have been observed, and it is recorded that in Garhwal the white secretion is eaten and is, in Narsingpur, believed to have narcotic properties.

P. viridula, Atk., is recorded from Poona. *Flata ferrugata*. Fabr., is a small "dead leaf coloured" insect not uncommon in Western India. The very common plains species with greenish-white tegmina belong to the genus *Melicharia* and apparently principally to *M. lutescens*, Wlk. Nothing appears to be known as to their life-history though they are common in cultivated areas. *Ketumala bisecta*, Kby., is found on grass.

Delphacinæ.—A long robust mobile spur on the apex of the hind tibia. These small insects are so insufficiently known that our common

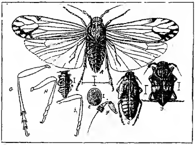

Fig. 503—Liburnia psylloides. A. Imago B. C. D. Nymphs. E. Eggs. F. Antenna. G. H. K. Legs. (I. M. N.)

species appear to be largely unrecorded. They are small delicate insects with narrow wings as a rule, found abundantly in grass and on green plants. At least one species of *Pundaluoya* is common, while *Purohita cervina* has been found breeding on green shoots of bamboos in the plains. The eggs are laid in clusters of white mealy wax on the shoots and, in Behar, the insect hibernates in this stage. *Liburnia* (*Delphax*) *psylloides*, Leth., was described from Ceylon where it injures maize as it does also in India. It breeds sufficiently rapidly in young plants to become a pest, though not so serious on one as *D. sacchari*. West., of the West Indies which destroys sugarcane. There are probably a large number of this sub-family awaiting discovery in the plains and it is likely that these little insects may be found to play an important part as pests of grasses and small cereals.

Collecting.—Almost no family will so well repay study from every point of view: much collecting and systematic work must be done before we can know our common species and the life-histories of all are worth careful study. Imagos require careful pinning and preservation, but no special methods of collecting are necessary except careful observation. Life-histories must be observed on the growing plant, but this has been successfully done in some cases.

MEMBRACIDÆ.

Tarsi three-jointed; prothorax produced backwards into a process. Ocelli placed between the eyes, antennæ in front of and between the eyes.

These small insects are as a rule recognisable at once by the bizarre form assumed by the prothorax, which is developed into a distinct process posteriorly and often into two thorn-like processes laterally. The position of the antennæ and ocelli must, however, be examined and the student will readily confuse our common forms with *Machærota* in the next family in which the scutellum is produced into a backwardly directed spine and the imago very closely resembles some Membracids in general appearance. Our common species are all small dull-brown insects, often with a peculiarly close resemblance to stiff thorns, their attitude on the plant aiding the resemblance. It is probably accurate to believe that they are protected by the fact that when at rest on the twig of a plant they give the appearance of stiff thorns, often recurved and while the plants they feed on often have no thorns, yet these insects may have originated upon thorn-bearing plants and maintain the structures and resemblance which are still useful to them.

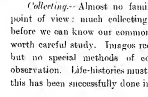

Fig. 504.—LEPTOBELUS DAMA.

The length rarely exceeds 10 m.m., usually being about 4 to 6 m.m. ($\frac{1}{6}$ to $\frac{1}{4}$ inch). The head is small, concealed by the greatly developed prothorax; the latter is produced posteriorly into a long sharp process which may lie close to the wings, being concave above or be convex above and curve down to the apex of the wings; anteriorly there is often a single upright process which may curve backwards high over the body, or be produced laterally into spines, both occurring together in one genus (*Leptobelus*); more often the prothorax is produced anteriorly into two divergent thorn-like process, curving forwards, laterally or backwards: in many the prothorax is not produced anteriorly. The scutellum is obsolete or concealed in one sub-family (*Membracinæ*), the tegmina and wings are often comparatively small, hyaline and distinctly veined; they are in repose placed at an angle over and against the abdomen, which is then concealed. Legs are well developed, short, and the insects can run rapidly along a twig or leap off suddenly, taking flight then to another twig. Males and females are similar in general appearance. In one Himalayan genus (*Darthula*), the abdomen is produced posteriorly into a long bristly process, whose function is not known.

Little is known of the life-history. We figure some stages of *Oxyrhachis tarandus*, Fabr. (Plate LXXVIII), a common species of the plains. In this as in other species eggs are laid in the bark of twigs of the food-plant, cuts being made in two rows at an angle, the eggs laid in the cut with the ends exposed; each egg is cylindrical with rounded ends, a spine-like process curving back from the end; this spine apparently serves to fix the egg in the plant but may have other functions. The young are found gregariously with the adults near the eggs; they are brown and shiny, the body apparently covered with moisture; the abdomen terminates in a telescopic tube, tipped with red, from which issues the liquid excretion which ants love; the red tip suggests a device to attract the ant, since it is visible only when the telescopic tube is extended before the liquid issues. In one sub-tropical species (*Hypsauchenia subfusca*, Buckt.), the young are very like small cockroaches (Blattids) with a prominent pair of cerci, with no sign of any pronotal prominence, the body flattened and rounded. The adults constantly remain motionless on the plant until disturbed, often in clusters; they extract sap from the twig they are on and are more or less gregarious in habit. Females have been observed to rest on or near the eggs until they hatch, and apparently this is the normal habit in this species. The length of the life-history is not known but development occupies some weeks normally, and while the number of eggs laid is large, increase in number does not appear to be very great or rapid. Breeding has been observed at all times of the

PLATE LXXVIII.—OXYRHACHIS TARANDUS.

Fig 1. Eggs laid in twig of babul (*Acacia arabica*).
,, 2. Nymph five hours after emergence, x 50.
,, 3. Eggs, removed from plant, immediately after being laid (left), before hatching (right).
,, 4. Nymph, second instar, x 18.
,, 5. ,, third ,, x 16.
,, 6 Imago.
,, 7. Head of imago from in front

1

3

5

2

6

year and no definite seasons are known; there is some reason to believe that continuous multiplication is not possible since a supply of plant sap is not always available; *i.e.*, that these insects breed at seasons when the supply of plant sap is large, there being a relation between the plant and the insect in this respect. Food-plants have been little observed and the common species are probably considerably polyphagous. They are found on trees as well as shrubs and the more bushy herbaceous plants. None can be reckoned as pests to agriculture, as no case has yet been seen of their occurrence in sufficient number to materially injure a plant, though they are common in the plains. Little is known of their enemies; Hymenopterous parasites were obtained from the eggs of *Leptocentrus taurus* but no other enemy is recorded.

The Indian species have been recently monographed by Distant in the Fauna of India: 117 species are described, from India, Burmah and Ceylon, of which about 10 are known to occur in India exclusive of the hills. The records of occurrence of species in the plains are however very meagre, as, exclusive of Calcutta and Bombay, nearly all the species collected have been from hill localities. There is a large field for collection in the plains and many species to be found. Distant recognises two sub-families, the *Membracinæ* in which the scutellum is obsolete or concealed, and the fore tibiæ dilated, the *Centrotinæ* in which the scutellum is distinct, the apical angles acute. Of the former, the student will find only *Oxyrhachis* in our fauna, represented by *O. tarandus*, Fabr., a brown insect with the posterior pronotal process curved up from the apex of the wings, the anterior lateral processes in the form of short tricarinate thorns.

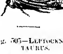

Fig. 505—LEPTOCENTRUS TAURUS.

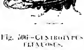

Fig. 506—CENTROTYPUS FLEXUOSUS.

This species is common in many localities, breeding upon pigeon pea (*Cajanus indicus*), babul (*Acacia arabica*), laburnum (*Cassia fistula*). We figure the stages; the eggs can be readily found, the female usually remaining over or near them until they hatch. Of the Centrotinæ we figure *Leptocentrus taurus*, Fabr., which, with *L. substitutus*, Wlk., is found

PLATE LXXIX.—MACHÆROTA PLANITIÆ.

Fig. 1. Eggs embedded in the tissues of cotton stem. x 2.

„ 2. An egg embedded in the tissues. x 6.

„ 3. An egg magnified 8 times.

„ 4. The Nymph 19 days after hatching.

„ 5. The calcareous habitation of the Nymph, with a supplementary tube below for drawing in air, x 7. Tube 20 days old.

„ 6. Calcareous tube with the last moult attached to it. Moulted skin enlarged 7 times.

„ 7. The male. x 5.

„ 8. The female. x 5.

„ 9. Lateral view of the imago (female), x 7½, showing the curved scutellar spine.

on bushes in the plains. *L. taurus*, Fabr., breeds on sissu (*Dalbergia sissu*), ber (*Zizyphus jujuba*) and on brinjal (*Solanum melongena*) ; the nymph is green and is often kept in leaf-nests by the red ant (*Oecophylla smaragdina*). *Gargara mixta*, Buckt., is a small form, with no lateral processes, found breeding upon sissu (*Dalbergia sissu*).

That extraordinary insect *Darthula* is placed in this family, though its habits agree with the Cercopine division of the next family. It is a large red-brown insect, with a long black process at the apex of the abdomen ; seen solitary there is marked mimicry of a fallen withered bramble-leaf, the process being the hairy leaf stalk ; but the insect lives gregariously upon the Himalayan alder (*Alnus nepalensis*), where the clusters present a most grotesque appearance with the bristly processes sticking out at all angles. Like the *Cercopinæ*, these squirt out fluid when agitated. The species is not a tropical one, occurring in the Himalayas.

CERCOPIDÆ.

Ocelli two, on the vertex. Third tibiæ with stout teeth and short spines at the apex.

The absence of the double row of spines on the hind tibiæ distinguishes this family from the next, while the simple prothorax distinguishes it from membracids. There is a characteristic appearance about the plains species which enables them to be recognised easily in the field. Most are small, wedge-shaped insects, commonly "dry-grass colour" ; the larger and more brilliant forms occur in the hills or in submontane forest areas ; these constitute a markedly separate division, and it would not be difficult to divide this family into three separate families ; the *Machærotinæ* have the scutellum produced into a spine, and live in tubes when young ; the *Aphrophorinæ* have the anterior margin of the pronotum rounded or angulate ; the adults are found in grass and low vegetation, and have great powers of leaping ; the nymphs live in "*Cuckoo-spits*" ; the *Cercopinæ* have the anterior margin of the pronotum straight and have the eyes

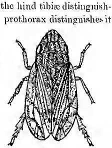
Fig. 507—CLOVIA BIPUNCTATA, × 4.

nearly round; they live a free life upon trees and bushes, the nymphs active. We discuss these divisions separately. Nothing is on record as to the enemies of *Cercopidæ*: none are really injurious, though *Machærota* is sometimes abundant on cotton.

Distant lists 130 species from India, Burmah and Ceylon (Fauna of India, Rhynchota, Vol. IV), but there are many more to be found and described, even in the plains. One of the most interesting species is *Machærota guttigera*, Westw., described as making tubes on plants in Ceylon. (Trans. Ent. Soc., London, 1886, p. 329). *M. planitiæ*, Dist., is common on ber (*Zizyphus jujuba*), on bael (*Ægle marmelos*), on cotton and other plants in India. The egg is laid on the twig, the nymph producing a liquid excretion which it forms into a small whitish tube, in which it lives; it is in fact a "spit-insect" in which the liquid excretion dries to a solid substance. We figure all stages of this insect, which may be seen commonly in the plains. (Plate LXXXIX.)

Aphrophorinæ.—These are small "dry-grass" coloured insects whose immature stages are commonly passed in a mass of bubbles of liquid, produced by the nymph itself on its food-plant. The common species are found on grasses, the white mass of bubbles enclosing the flattened whitish nymph. The details of the metamorphosis are not known for any Indian species. *Poophilus costalis*, Wlk., is widespread and common; *Ptyelus nebulosus*, F., is a little smaller and darker; *P. subfasciatus*, Wlk., and *P. affinis*, Dist., have the tegmina mottled dark and light. *Clovia puncta*, Wlk., is the smaller extremely common species, dry-grass colour with a single black speck near the apex of the tegmen. *C. bipunctata*.

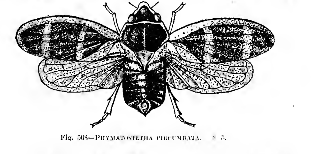

Fig. 508—PHYMATOSTETHA CIRCUMDATA. × 3.

Kby., is less common but is found in the plains. *Aphrophora* occurs more sparsely, *A. sigillifera*, Wlk., being the common species.

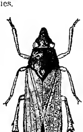
Fig. 509—ABIDAMA PRODUCTA. × 3.

The *Cercopinæ* include the large brightly-coloured forms of the genera *Phymatostethus* and *Cosmoscarta*, which are wholly hill forest insects and the smaller, fragile forms of the genera *Abidama* in the plains, of *Callitettix* and *Eoscarta* in the hills.

Abidama rufula, Dist., and *A. producta*, Wlk., are fragile inconspicuous insects, found at light or on grass; the former is brown to black, the latter has red tegmina edged with black. They are nocturnal insects, found on grass by day; their life-history is wholly unknown. In the hills, the large species of *Cosmoscarta* are very conspicuous; they are found abundantly on trees and excrete a very noticeable amount of liquid honey-dew.

JASSIDÆ.

Ocelli placed on the front margin of the head. Posterior tibiæ with a double row of spines.

This family includes a large number of small linear insects, easily recognisable by the spiny tibiæ. They are of varied colouring, almost always cryptic, in a few sub-tropical forms warning. Green, "dry-grass" colour and similar tints prevail in those which live on bushes or in grass; those living on bark are speckled with black, while those which form part of the surface-soil fauna are black. The body is usually narrow and with parallel sides, the wings tightly folded round the abdomen; the head is broad, closely united to the prothorax as in most leaping insects, the antennæ thread-like, small and inconspicuous. The legs are well developed, and the hind pair are formed for leaping much as in the Acridiids. Males and females are similar, the former with clasping organs, the latter with a concealed ovipositor.

Little is known of the life-history; the eggs are, in the known species, laid in the soft tissues of plants: the nymphs are active, found running actively on the plant. The number of moults and the details of the metamorphosis are not known for any Indian species; the transformations of *Idiocerus* are wholly passed on the mango tree and the nymphs of other species are commonly seen on their food-plants. *Idiocerus* has a curious cycle, as there is but one brood yearly on mango in the early hot weather and the imago lives over on the tree for the rest of the year. It is possible that this occurs also in many other species, and it is probable that there is a very close inverse relation between the vigour of the host plant and the prosperity of the Jassid species. Hibernation appears to occur usually in the imago stage, but there is very little accurate information on this point. Equally little is known of the parasites or enemies of this family.

These insects are found commonly in grass, low vegetation, on the soil, more rarely on trees; their food-plants are little known: *Idiocerus* is found on the mango tree and other species specially feed upon rice, cotton, etc. They are of little economic importance, the species attacking mango destroying the blossom, the species attacking cotton causing a curling of the leaf of the broader-leaved varieties (American and tree cottons), as does the species attacking Castor; as with other small sucking insects, there is a marked relation between the vigour of the host plant and the amount of Jassids attacking it, and it has been often observed that weak plants are more infested than vigorous ones (see Indian Insect Pests, page 109). The number of Jassids in pasture is sometimes enormous, and it is possible that injury is caused in such cases, though we are not aware that it has ever been proved.

Distant has recently described the Indian forms in Volume IV of the Fauna of India; we are aware of no published information on this family except descriptions of species, which are all referred to by Distant. Large numbers of species probably remain to be described since the plains fauna especially has been little collected and it is very extensive, probably equal to the sub-tropical fauna.

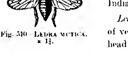
Fig. 510. LEDRA MUTICA. × 1½.

Distant enumerates 340 species in the Fauna of India, Vol. IV, of which 54 are actually recorded from localities in tropical India, chiefly from the Pusa collection.

Ledrinæ.—A small number of species of very marked facies, the broad foliaceous head specially distinguishing our species.

Ledra mutica, Fabr., is a dry-grass-coloured insect, speckled with grey, found not uncommonly and which occasionally comes to light. It is a comparatively large insect, measuring two-thirds of an inch in length, with a flat spear-shaped head. The green foliaceous semi-transparent nymphs have been found on mango but sparsely.

Bythoscopinæ.—The head is much deflexed, the vertex almost absent, the ocelli on the face. Tegmina membranaceous.

Idiocerus clypealis, Leth., *I. niveosparsus*, Leth., and *I. atkinsoni*, Leth., were described from specimens attacking mango shoots in Saharanpore (I. M. N., I., 4). These small insects occur in great abundance in some seasons, and mango trees then contain vast numbers which fly out in a cloud when disturbed. They feed on the sap of the young growing shoots specially, and the developing flowering shoot naturally attracts them. When really abundant, the amount of sap they extract is sufficient to prevent the shoot growing, and the whole crop is lost owing to the destruction of the flowers. They occur practically throughout India and are abundant only in some years and in the hot weather. Their eggs are laid in the soft shoots and the moults of the nymphs are undergone on the leaves, the cast skin remaining behind on the leaf. It is now known what their seasons are ; in Behar there is one brood in the early hot weather (March—April) and the adults then live over on the tree until the next year. They have not been found to breed in the interval and regular observation has shown them to remain alive throughout the year as adults sitting on the bark or leaves.

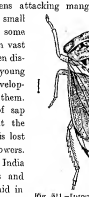

Fig. 511.—IDIOCERUS NIVEO-SPARSUS.

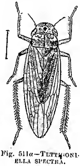

Fig. 511*a*—TETTIGONIELLA SPECTRA.

Tettigoniellinæ.—The ocelli on the vertex of the head, the face prominent and convex. *Tettigoniella spectra*, Dist., is the common rice

Jassid, an almost white insect, about one-third of an inch long, found abundantly on this crop and in grass. It is widely spread in India and is at times found in such abundance that it may almost be put down as a pest and will probably rank as a destructive insect when it is exceptionally abundant. It is the sole example of this large genus, so well represented in sub-tropical India, which is really widespread in the plains. *Kolla mimica*, Dist., is extremely like the foregoing species, but is not known to have its wide distribution; students will certainly confuse it and should bear in mind Distant's remark: "It is however to be generically separated by the angular vertex, the lateral margins of which are in a line with the outer margin of the eyes."

Gyponinæ.—The three tropical Indian species are so distinct that, though the ocelli are on the vertex, they will be readily recognised.

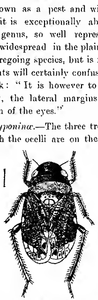

Fig. 512—PENTHIMIA SUBNIGER.

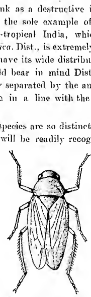

Fig. 512a—KRISNA STRIGICOLLIS. × 3.

Penthimia compacta, Wlk., *P. subniger*, Dist., and *Neodartus acocephaloides*, Mel., are dark-coloured rather broad insects, flattened and not slender, which are found on soil and among fallen leaves, or which come rarely to light. They are rather sluggish insects and form part of the immense surface soil fauna, unlike most of this family.

Jassinæ.—Ocelli placed on or at the anterior edge of the head. *Mucaria splendida*, Dist., will be confused with the last species unless the ocelli are looked for when they will not be found. It is a rather broad black species, so far known only from Pusa. *Hecalus* is represented by a single green species with the broad head of *Ledra*, but which is easily distinguished by the absence of the ocelli from the head above. *Thomsoniella* is represented by two small dull green species, so far known only from Bengal, but probably far more widely spread. *Selenocephalus virescens*, Dist., is known from Bengal and Assam, a dull green species with a groove across the apex of the head. *Krisna strigicollis*, Spin., is a larger dry-grass coloured insect, more than half an inch long in large specimens, widely spread in tropical and sub-tropical India. *Goniagnathus punctifer*, Wlk., is a broader brown insect, widely spread over the plains, as in the hills; *Varta rubrofasciata*, Dist., is a larger green insect, the tegmina with red lines found as yet only at Pusa.

Nephotettix includes the green species which are so well known to Calcutta residents as the "fly" which comes in hordes to light towards the close of the rains. Two species are concerned, *N. bipunctatus*, Fabr., in which the female is green, the male green with two black spots and *N. apicalis*, Motsch., which is green, much marked with black. They come freely to light and in the humid heat of Lower Bengal multiply immensely and are a distinct plague. *Deltocephalus* and *Paralimnus* are recorded from the plains.

Typhlocybinæ.—" *The Typhlocybinæ* are readily separated from all the other sub-families of the Jassidæ by the four longitudinal veins or sectors of the tegmina which run to the transverse veins defining the apical cells without branching, so that there are no ante-apical cells and also by the absence of supernumerary cells in the wings. "—(Gillett in Distant.)

Empoasca flavescens, Fabr., is the well-known " Green fly " of tea, recorded by Distant from India, Ceylon, East Africa, Brazil, Europe, Britain, United States and the whole Palearctic Region. It is one of the insects which by sucking the apical shoot check the growth of tea and lessen the yield, though improving the flavour. Ordinary contact poisons check it readily. The very delicate green nymphs are common on tea, but it is not easy to be sure how much damage is really due solely to this pest. *Empoasca notata*, Mel., is a common insect on castor. The eggs are laid in the soft tissues of the leaf mid-rib and the bright green nymphs suck the leaves, causing curling and distortion. The imago is green, with only dull white markings on the vertex and

prothorax. The insect is a pest to some varieties of castor especially, but is not usually destructive to castor grown as a field crop. *Typhlocyba sudra*, Dist., is sometimes curiously abundant on *Bauhinia* and it is a striking commentary on the dependence of these sucking insects on their food-plants to see a tree with the leaves yellow and withering from the depredations of this insect when none live on neighbouring trees. Annandale records their occurrence in Calcutta and we have seen a remarkable case of this kind at Pusa, a tree with every leaf covered with them in all stages and which put forth and maintained healthy foliage only after thorough spraying.

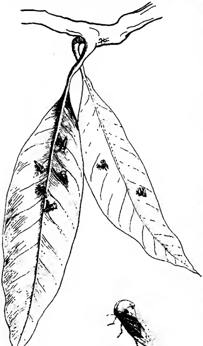

Fig. 313—IDIOCERUS CLYPEALIS. (F. M. H.)

Collecting.—There is much to be done before the Jassids of tropical India become properly known and the number of species recorded only from Pusa or Calcutta in tropical India shows how little the family has been collected in the plains. Still more is there room for life-history and bionomic work and no group offers such facilities for research on the relation between the vigour of the plant and its immunity from these and kindred pests.

PHYTOPHTHIRES.

The smaller Homoptera, of the families *Cercopidæ* and *Membracidæ*, lead into a series in which the active habits of the larger *Homoptera* are replaced by a method of life in which the insect is more or less fixed with a closer 'parasitism' of the host plant than occurs in the more active forms and in which there is a tendency to the development of wingless forms, culminating in completely apterous, usually inactive females. Correlated with this is a growing differentiation of the inactive pupal stage, leading to the almost wholly inactive male 'pupa' of *Coccidæ*. Taking these together, there is sufficient justification for separating off as a single group the dimerous and monomerous families of *Homoptera*, with a clear understanding that they are not so widely separate from the trimerous families as perhaps the *Coccidæ* themselves are from the dimerous families. It is probable that strictly we should separate the *Coccidæ* as a division equal in value to the two, *Trimera* and *Dimera*, but this would be for our present purpose inconvenient. An obvious structural character separating the Phytophthires from the Homoptera is the antenna, in the former long, usually with 8 to 10 distinct joints, in the latter short, with a basal joint and a bristle-shaped process.

Phytophthires, as here constituted, are marked by modifications of habits and structure which accord with a more specialised parasitism to their host plant; in the *Psyllidæ* we get flat inactive scale-like forms, often gall-insects, in which locomotion is greatest in two stages, the very young larvæ and the winged males and females, but which does occur in all stages; in the *Aphidæ*, the phenomenon of parthenogenesis appears, combined with the viviparous habit and the apterous female adult, but this is combined with winged males and females and production of fertilised eggs; the apterism, viviparism and parthenogenesis displayed are found when abundant food and suitable climate are favourable to quick reproduction and an easy life on the growing plant, when locomotion is not required and the organism devotes itself to its parasitic activities; when these conditions disappear, the characters of the higher, less degraded organism are developed to meet the less easy conditions of life.

In *Aleurodidæ*, the active periods are limited to the young nymph and the winged adult, both sexes are winged and egg production is the rule; but the parasitism shows itself in the reduction of moults (as in all of this division), in the immobile nymph firmly protected by a 'scale' and living gregariously fixed to one part of the plant.

In *Coccidæ*, the parasitism is at its height; in a number we find that parthenogenesis is a frequent occurrence, that the nymph is active only in the youngest stage, that the female is a simple sac, producing eggs, that a scale or other covering is present and that the male alone is free-living and winged; the insects live gregariously fixed to the plant and viviparous reproduction is not uncommon.

Until the physiology of the pupal period is investigated in greater detail it is impossible to judge how far the metamorphosis is really perfected, but there is a growing differentiation, both in the Phytophthires as a whole and in Coccidæ themselves of the metamorphosis, though the wings are developed outside: there is not quite a sudden change from the wholly apterous nymphs to the 'pupa' with large free wing-rudiments, since the insect makes its cocoon after the last nymphal moult (not before, as in truly metabolous insects) and since it is active after the pupal moult and can move away to shelter before the wing pads emerge; but the whole process of wing development and of 'metamorphosis' takes place not during the last three instars as in most Homoptera, but during the last alone, the insect being then immobile. This is, in essence, an incomplete but advanced metamorphosis, and if we regard *Coccidæ* as being linked on to the Homoptera, then we must regard the Phytophthires as showing a growing tendency to a metamorphosis and thus to an approximation to the higher and metabolous insects. We are of the opinion that the group show a marked adaptation to a 'parasitic' existence, visible in the differentiation of the male metamorphosis and in the simplification of the female life, the first to secure the perfect winged form, the latter to secure the undifferentiated egg-sac. If this view be correct, the division is moving, not to an approximation with higher forms, but to an increased degradation, an adaptation to an inactive and parasitic existence. There is, however, no reason to believe that *Coccidæ* have sprung from a separate stock as some would have us believe, and we may regard them as being the present apex of one branch of the Homoptera.

PSYLLIDÆ.

Small insects, with one or two pairs of wings in both sexes, without siphons; the nymph is flattened, partially active in all stages.

These are small insects, of infrequent occurrence, found in galls or on plants. The antennæ are moderately short, the head with compound eyes and a beak, the thorax well-developed with one or two pairs of hyaline wings in which are two or more veins. The abdomen is well developed, and the legs are formed for running, not leaping. Males and females are similar in general appearance. The life-history is known in few species: the nymphs are flattened, the wing-pads visible in the last three instars; the legs are well developed and the nymph can walk. Some are free living, found on the leaves and twigs of plants, others live concealed in galls; the latter are probably predominant and a large number of galls in India are the work of this family. No species has been carefully studied and very few are even known. In the present state of entomology, their identification is practically impossible and the Indian species are almost wholly unrecorded. The family has little direct economic importance, one species being destructive to indigo seriously in some seasons, another occurring on citrus plants. We figure two species occurring in galls on *Alstonia scholaris* and *Ficus glomerata*; several others are known, both

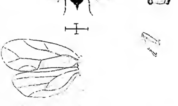

Fig. 514—PSYLLA CISTELLATA. (I. M. N.)

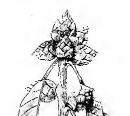

Fig. 515—GALLS CAUSED BY PSYLLA CISTELLATA ON MANGO. (I. M. N.)

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gall-insects and free-living species, besides those recorded below. (Plate LXXX.)

Kieffer has described *Phacosema gallicola* as causing a gall on the leaf of *Cinnamomea* sp. in Trichinopoly (Zeit. Wiss. Insectenbiol. II, 388) making a new sub-family, *Phacoseminæ*, for this and for *Phacopteron lentiginosum*, Buckt. The family is usually divided into *Psyllinæ*, *Aphalorinæ* and *Triozinæ*, according to the venation. *Psylla isitis*, Buckt., was described from the full-grown nymph of an insect said to destroy indigo. The species has been found on indigo since then and causes the terminal shoot and leaves to curl, all growth ceasing in bad cases. *Trioza* (*Psylla*) *obsoleta*, Buckt., is recorded on *Diospyros melanoxylon* in Thana (I. M. N., V. 35). *Psylla cistellata*, Buckt.. is referred to (I. M. N., III, 13) as causing galls on mango shoots in Dehra Dun. We reproduce the original figures of this species, which has been found sparingly in Behar also. *Phakopteron lentiginosum*, Buckt., was described from species regard from galls on *Garuga pinnata* in Poona (I. M. N., III, No. 5, p. 18).

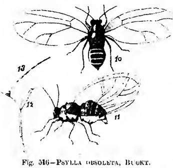


Fig. 516—PSYLLA OBSOLETA, BUCKT.

Kieffer describes Indian gall-making Psyllids (Ann. Soc. Bruxelles. 1905. XXIX. p. 160, etc.): *Cecidopsylla schimæ*. *Neotrioza machili*. *Ozotrioza styracearum*, *O. laurinearum*. *Pauropsylla ficicola*. *P. globuli* and *Psylla cedrelæ*. are the new species.

APHIDÆ.—*Plant lice. Green fly.*

Small insects, often wingless, the tarsi with two joints, the abdomen usually with a pair of abdominal siphons.

These insects are readily distinguished by the rounded form and pair of siphons. They are small, rarely more than one-tenth of an inch long, and coloured in dull yellows, greens and black. The head is distinct, with long straight antennæ, small compound eyes, and long thread-like mouthparts extruded from a short proboscis. The thorax and abdomen are robust, the latter having a pair of 'siphons' on the dorsal surface; there is a short tail-like structure on the lower surface, the *Cauda*. The legs are long and the insect walks slowly. Wings are long, with few veins, usually hyaline with pearly reflections. Wingless individuals are very common and occur with winged ones. The life-history presents peculiar features, adaptations to the 'parasitic' mode of life of these insects. The females are, as a general rule, parthenogenetic, producing eggs and young without the intervention of a male. Generally young are produced which are females; the development may be very rapid, there being but few moults, and after the lapse of three days the female often commences producing living young, which will after the lapse of three days in turn produce young. This occurs normally in our common aphides which live on mustard, wheat, and cotton.

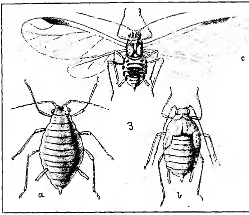


Fig. 517—RHOPALOSIPHUM DIANTHI. (I. M. N.)

In temperate climates, there is often a brood of both sexes, of which the females produce eggs; this brood normally occurs before the winter and the eggs survive the cold winter. This has not been shown to occur in India and there is as yet no evidence that such likely is to occur; some of our species are temperate forms which are active only in the cold weather and have to live over, not cold but hot weather; others are active throughout the year when food is available. The commonest aphides appear to have no sexual generation in the plains and, though much is obscure, it is at present reasonable to believe that the altered climatic conditions produce different sexual habits. Aphides are universally plant feeders, living on the sap of plants. Several common cultivated plants are very seriously attacked and it is doubtful if any cultivated plant will not be found to be the host of some species.

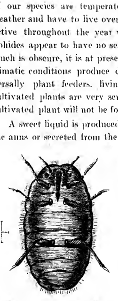


Fig. 518 – RHIZOBIUS ARALIÆ.
(I. M. N.)

A sweet liquid is produced by these insects and is either excreted at the anus or secreted from the siphons. This liquid (honeydew), which is produced by many homopterous insects, is a favourite food of ants. Certain species of ants derive a large part of their food from aphides and it is not uncommon to see the aphides cared for by the ants, shelters built for them and their enemies kept off. Many have more intimate relations with ants but our common species are free-living and are only visited by ants. Many other insects feed on the honeydew when it falls in abundance on the leaves, but only ants are known to obtain it direct from the siphons of the aphides. The enemies of aphides are proportionate to their enormous power of increase and are the sole check upon them. Aphides are parasitised by Braconids, are devoured by the larvæ and imagines of Coccinellid beetles, by the maggots of Syrphus and other flies, by the grubs of the Hemerobiids. Fungoid diseases destroy them under favourable conditions and birds have been seen to eat them. Were it not for these checks the aphides would, under their ordinary rate of increase, render the earth uninhabitable within a short time.

The classification of *Aphida* is a disgrace to modern entomology, and the group has not been properly studied in recent years. Buckton's British Aphides deals with the group as a whole, but the genera are founded on insufficient characters, and the discrimination of species, largely on very variable colour varieties, is extremely difficult. The group requires to be properly monographed, the genera and species to be founded on definite structural characters. Few species of Indian aphides are recorded and the known species are here summarised; it is certain that there are many more species (especially in sub-tropical India), and there is a very large field of work in the biology of these extremely important and interesting insects.

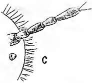


Fig. 519—RHIZOBIUS JUJUBÆ ANTENNA. (I. M. N.)

The wheat aphis (*Macrosiphum granarium*, Kby.) is found on wheat during the cold months, infesting the leaves and ears. As the ears ripen with the warmer weather, they fly away to the doob grass and feeding for a little on this plant, hide away on the surface of the soil. In what stage they remain until November has not been ascertained, but they reappear then on the wheat and it is probable they pass these months in the adult stage. The Cotton Aphis (*Aphis gossypii*, Glov.) is a cosmopolitan insect which breeds freely at all seasons of the year if food is available. It has been found on cotton and cucurbitaceous plants and may have other food-plants. *Schizoneura lanigera*, Hausm., the so-called

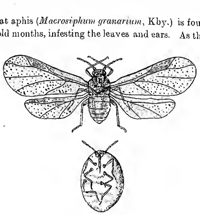


Fig. 520—PEMPHIGUS NAPÆUS. (I. M. N.)

"**American Blight**" or "woolly louse" is stated to occur in South **India** and to have been extremely destructive; a great deal has been written about this pest in temperate climates, and what is known of it in India will be found in Indian Museum Notes, II. p. 52.

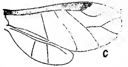


Fig. 521—CHAITOPHORUS MACULATUS WINGS.

Buckton described *Rhizobius jujubæ* from the roots of ber (*Zizyphus jujuba*) and also recorded the European rose aphis (*Siphonophora rosæ*) from India (British Aphides, Vol. IV). Though occurring outside the limits of the plains, we may notice the gall-making aphid on *Pistachia terebinthus* described by Buckton as *Pemphigus ædificator* (I. M. N., III, 71) as well as *P. napæus*, Buckt., and *P. immunis*, Buckt., on Poplar and Aspen in the Himalayas (I. M. N., IV, 50). *Oregma bambusæ*, Buckt., is described as attacking bamboo in Dehra Dun. (I. M. N., III, 87.)

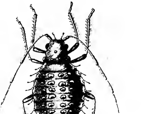


Fig. 522—CHAITOPHORUS MACULATUS WINGLESS FORM.

Buckton also described *Chaitophorus maculatus* (I. M. N., IV, 277), which attacked lucerne in Jodhpur. It is a frequent pest to lucerne in other parts of India where this crop is grown for fodder. The following is a list of definitely recorded or identified species :—

Macrosiphum sonchi, L.	on	Safflower.
Toxoptera aurantii, Boyr.	,,	Orange.
Aphis gossypii, Glov.	,,	Cotton, Cucumber, etc.
,, *rumicis*, Linn.	,,	*Vigna catjang*. *Benincasa cerifera*.
.. *adusta*, Zehnt.	,,	Juar.
,, *cardui*, Linn.	,,	Pigeon pea
,, *brassicæ*, Linn.	,,	Radish.
.. *malvæ*, Pasc.	,,	Bhindi.

Nyzus nerii, Boyr.	on	Ak. (*Calotropis*).
Macrosiphum granarium, Kby.	,,	Wheat, barley, etc.
Chaitophorus maculatus, Buckt.	,,	Lucerne.
Rhizobius jujubæ, Buckt.	,,	Ber (*Zizyphus jujubæ*).
Ceylonia theæcola, Buckt.	,,	Tea.
Schizoneura lanigera, Hausm.	,,	Apple.
Pemphigus ædificator, Buckt.	,,	*Pistachia terebinthus*.
,, *napæus* ,,	,,	Poplar.
,, *immunis* ,,	,,	Aspen.
Siphonophora rosæ, Ream.	,,	Rose.
Rhopalosiphum nymphеæ, Fabr.	,,	Aquatic plants.
,, *dianthi*, Schr.	,,	Rape.
Oregma bambusæ, Buckt.	,,	Bamboo.

ALEURODIDÆ.

Mealy wings. Tarsi two-jointed. Both sexes winged, with few veins. Nymph in a scale with a vasiform orifice.

This is a family of small insects, difficult to distinguish in any but the adult winged stage from *Coccidæ*. The adults have two pairs of wings, with at most two veins in each; this separates them from *Coccidæ* in which the male has but one pair of wings, the female none, and from *Psyllidæ*, in which the wings have more than two distinct veins. The adults are small moth-like insects, with floury wings, usually white, sometimes with black or grey spots or bands.

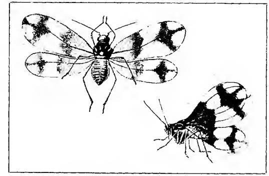


Fig. 523—ALEURODES NUBILANS. (I. M. N.)

PLATE LXXXI.—ALEURODES RICINI (NOM. NUD.).

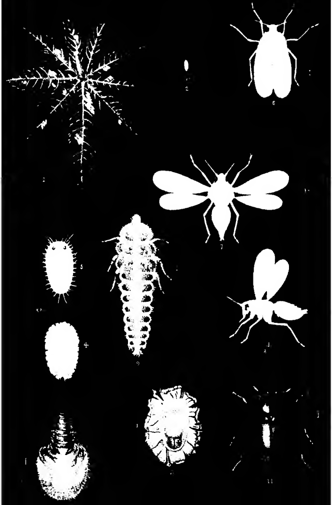
CASTOR ALEURODES.

Fig. 1. Eggs on a young castor leaf. x 8.
,, 2. A single egg. x 20.
,, 3. Nymph just hatched. x 80.
,, 4. ,, two days later with waxy fringe.
,, 5. ,, in last stage. x 25.
,, 6. Adult female.
,, 7. ,, male.
,, 8. ,, ,,

CLANIA SOROR.

,, 9. Larva that feeds on the Aleurodes nymphs.
,, 10. Pupa.
,, 11. Imago.

Figures 9, 10, 11, illustrate the Coccinellid beetle which specially feeds upon this mealy-wing.

2
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The antennæ are usually seven-jointed and moderately long; the compound eyes are distinct and there are usually two ocelli. The wings are of nearly equal size, with bristles or ornamentation at the margin, the thorax well developed. The abdomen is ovate and thickset, the vasiform orifice present (see below) the male with a short penis. Legs are of moderate length, the insects being able to walk and fly.

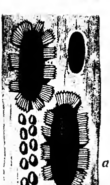

Fig. 524.—ALEURODES BARODENSIS EGG, NYMPH, PUPA. (I. M. N.)

Peal worked out the life-history of some species and more has since been learnt of this group. The eggs are usually attached to the leaf by a very short stalk and are smooth, shiny, oval in form. They are laid in clusters on the leaf, often in a circular band formed by the female revolving as on a pivot while depositing them. The young larva that issues is active, of the flattened oval shape of a Coccid larva, with legs and antennæ: it is active for a short time and moves about till it finds a satisfactory place when it settles down and fixes itself. It then moults and becomes a legless scale-like insect, flattened and pressed to the leaf; there is usually a development of wax as a covering, the wax being the product of dermal glands, as in the *Coccidæ*; this wax often takes very bizarre forms. The characteristic of this and the later immature stages is the "vasiform orifice," an opening on the dorsal surface of the abdomen leading into a space in which lies a narrow

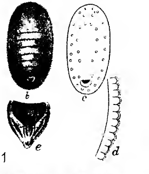

Fig. 525—ALEURODES BARODENSIS. B. Larva. C. Pores of larva. D. Margin of larva. E. Vasiform orifice and operculum. (I. M. N.)

structure, like a tongue (the *lingula*) from which honey-dew is secreted: this orifice is covered by a hinged plate (the *operculum*). In this state the nymph has its rostral setæ buried in the tissues of the host plant, and feeds on the sap it extracts. In addition to producing honey-dew, it produces the wax it is covered in; it is apparently uncertain whether honey-dew is or is not distinct from the excreta; it is stated to be so in *Psyllidæ*, but not in *Aphidæ*; we believe it is not distinct in *Coccidæ* or *Aleurodidæ* in all cases.

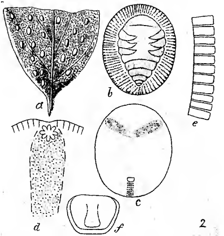

Fig. 526—ALEURODES EUGENIÆ VAR AURANTII. A. Pupæ on leaf. B. Pupa case. C. Diagram of pupa case. D. One radiating patch of C. E. Margin of pupa case. F. Vasiform Orifice, operculum and lingula (diagrammatic). (I, M. N.)

In the nymph state there are two moults, followed by a moult leading to the pupa stage, *i.e.*, there are in all the following instars :—

1st instar, active, followed by 1st moult.
2nd ,, scale-like, followed by 2nd moult.
3rd ,, scale-like, followed by 3rd moult.
Pupa ,, in the scale, followed by 4th moult.
Winged imago.

There are only small changes at the second and third moults, but the insect in the puparium is a definite pupal form, inactive, with wings, legs and antennæ being formed outside the body. From it the imago emerges, with fully formed rostrum and alimentary system, and leads an active life.

A great deal is obscure about these insects, and we cannot here go into further detail. Very little is known of the hibernation, of the length of life, of the habits of the imago, etc. Peal observed that the nymphs were parasitised by minute Chalcids and they are fed upon by beetle larvæ. Fungi also attack them (e.g., *Aschersonia* and *Sphærostilbe*).

Equally little is recorded as to the destruction caused by these forms. The Cane Mealy Wing (*Aleurodes barodensis*, Mask.) is occasionally a serious pest in many parts of India: the Castor Mealy Wing is occasionally destructive; tobacco is attacked by a distinct species; the Mango Mealy Wing is sometimes important, as is a black species attacking orange. None are known as serious pests to permanent crops such as tea, coffee, etc., and none are likely to injure quick-growing crops. The family therefore has not a very great importance, about equal to that of *Coccidæ*, but far less than that of *Aphidæ*, if we consider Indian Agriculture. "Black Blight," the fungus which covers the leaves of plants on which "honey-dew" has fallen, is a feature also of Aleurodid attack, and is confused with it.

The student should consult the "Contributions towards a Monograph of the Oriental Aleurodidæ" by H. D. Peal, in the "Journal of the Asiatic Society of Bengal," LXXII, pp. 61-98 (1903). It was his intention to have described other species including those mentioned here as attacking castor, mango and orange, but his death occurred when the work was in progress.

The following is a complete list of the recorded Indian species, as given in his Monograph.

1. *Aleurodes eugeniæ*, Mask., occurs on *Eugenia jambolana* in Poona. (Ind. Mus. Notes, IV. 52.)
2. *A. barodensis*, Mask., on Cane. (Ind. Mus. Notes, IV. 143.)
3. *A. eugeniæ* var *aurantii* on orange in North-West Himalayas. (Ind. Mus. Notes, IV. 144.)
4. *A. cotesii*, Mask., on rose, Quetta. (Ind. Mus. Notes, IV. 145.)

5. *A. nubilans*, Buckt., on betel (*Piper betel*) in Backerganj. (Ind. Mus. Notes, V, 36.)
6. *A. piperis*, Mask., Ceylon. (Trans. N. Z. Inst., XXVIII. p. 438. 1895.)
7. *A. religiosa*, Peal. (Journ. As. Soc., Bengal, LXXII. p. 67, 1903), on Pipal and Banyan in Calcutta.
8. *A. bengalensis*, Peal. (loc. cit.).
9. *A. Alcocki*, Peal., on banyan, Calcutta and Champaran (loc. cit.).
10. *A. quaintancei*, Peal., on Pipal (*Ficus religiosa*), Calcutta.
11. *A. simula*, Peal., on the Silk Cotton Tree (*Bombax malabaricum*), in Calcutta (loc. cit.).
12. *A. bambusæ*, Peal., on bamboos, Calcutta (loc. cit.).
13. *A. Leokii*, Peal., on indigo, Dalsingh Serai, Tirhut (loc. cit.).
14. *A. hoyæ*, Peal., on *Hoya* in Calcutta (loc. cit.).

Aleurodes bergi, Sign., has since been found and reared upon sugarcane in Behar, and other species occur on castor, mango and tobacco. A full account of the first has been published by Zehntner (Arch. Java Suiker-industrie, 14, p. 939 [1896], with coloured figures). Figures of the undescribed species occurring on castor in India will be found on Plate LXXXI.

COCCIDÆ.—*Mealy bugs and Scale insects.*

Male winged, with one pair of wings. Female wingless. Usually small insects, living motionless on plants and concealed or protected by a covering. Tarsus one-jointed with a single claw.

Scale insects, while rarely attaining very small dimensions, form part of the great number of insects that are sufficiently small to escape general attention. Many are not more than one-twentieth of an inch in diameter. Others are distinctly larger, of the size of a pea, while a few of the largest Indian forms have a length of one-half and even two-thirds of an inch. None can rank among the large insects, whilst the giants of the family (*Monophlebus*, *Walkeriana*, *Lecanium imbricans*, etc.) are conspicuous only when abundant.

Practically all are clothed in some form of covering, or bear large masses of material of their own production. The winged males are covered only in a thin powdering of wax. as are a few of the females. Many have a thicker coat of mealy material (*Monophlebus. Icerya. Pseudococcus*, etc). ; the bamboo scale (*Asterolecanium*) has a glassy covering ; the lac insects (*Tachardia*) produce an abundant covering of resinous matter; the wax scales (*Ceroplastes*) are enclosed in dense wax in plates; the shield scales. *Lecanium*. have a thickened dorsal surface, without wax; and a large number (*Diaspis. Aspidiotus*, etc.) have a scaly covering formed of felted threads and cast skins. The colour of this covering is often white or grey, rarely brightly coloured or noticeable; the insect within is usually

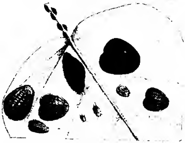

Fig. 527—YOUNG AND FEMALES, LECANIUM NIGRUM. × 3.

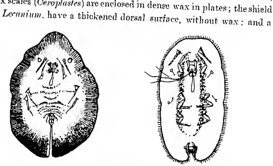

Fig. 528—LECANIUM WATTI (LEFT) AND ERIOCHITON THEÆ—VENTRAL. (*After Green.*)

brightly coloured, the colouring matter in the tissues showing through the skin. In such small insects, colour schemes appear to be of little importance though a few are cryptically coloured. In all, the females and males are sharply differentiated, the former inactive and wingless: the latter small, active and winged. In their first two stages they are indistinguishable, the structure being similar throughout the group (see Plate LXXXIII). The young are oval, flattened, with legs, antennæ and eyes; the form changes at the first moult, the body becoming flattened and adapted to the parasitic life on the plant. Antennæ, eyes and legs are no longer to be found in many inactive species, the mealy bugs and some active species retaining them. The female normally passes through three moults with small changes; the male after the second moult either gradually or immediately becomes a pupa; wing pads are slowly formed and the resting stage is entered on some days after the second moult. It is thus not a true pupa, but rather a resting nymph. The degree of degeneration varies with the species and the adult pregnant female is commonly a sac, firmly fixed to the plant by means of the suctorial apparatus. The anal opening is on the dorsal surface, the genital opening on the ventral. The spiracles are reduced to two pairs, on the lower surface, at the termination of air spaces that lead to the edge of the body; in some there are special spiracular processes which bear the spiracle at the outside of the covering. The mouthparts consist of the short beak-like rostrum from which fine suctorial threads arise. In the winged male the antennæ are long and many jointed; the eyes large; the body elongated and formed as in flying insects. The wings are narrow, with few veins; the second pair of wings is reduced to a hooked process which engages with the edge of the wing. At the end of the abdomen are frequently long many jointed cerci, one pair in some species, several pairs in a few (*Monophlebus*); the penis is often conspicuous and exserted. The mouthparts are absent and in their place is a pair of eyes.

In many species of *Coccidæ* reproduction is apparently similar to that of other insects. In a large number, however, we find that parthenogenesis is apparently general, the colonies consisting of females only, males not being commonly found and possibly occurring only at intervals. Very little is known accurately of such cases; the females produce enormous numbers of eggs and these eggs all hatch to females, which in turn produce female eggs parthenogenetically.

In other species males are abundant, often far more so than the females. Eggs remain for a longer or shorter time before hatching.

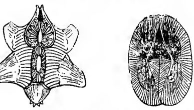

Fig. 529—INGLISIA BIVALVATA FEMALE. × 5—MALE PUPARIUM × 15. (*After Green.*)

In *Lecanium viride*, they hatch at once; in *Lecanium hemisphæricum*, they remain in the scale for several months and then hatching, development and reproduction goes on rapidly for several generations. Other species probably have seasons of rest and activity but these are not known.

The food of *Coccidæ* is the sap of plants, extracted from the tissues by the long suctorial threads. In a few cases, the presence of the coccid is shown by a swelling of the plant tissues, as if an irritant had been injected by the insect and a gall formed. In the case of *Dactylopius nipæ* on Cotton and Mulberry, the shoots are twisted and deformed, forming knots and loops in which the insects live. A subject deserving of investigation is the relation of the plant and its parasitic scale insect. There is much circumstantial evidence for the belief that strong and injurious plants are less attacked and more rarely infested than othe The precise means by which the plant effects this is unknown.

Coccidæ are the prey of a very large number of insects. The most noticeable are the Coccinellid beetles and larvæ, many of which feed exclusively upon *Coccidæ*. Lace wing flies (*Hemerobiidæ*) also attack *Coccidæ*; the larva of a small acalyptrate fly feeds upon the masses of eggs laid by mealy bugs. The larvæ of *Spalgis epius* (Lycænidæ), as of *Eublemma* (Noctuidæ) and of several *Tineidæ* feed upon mealy bugs and scale insects. Parasites are abundant, principally *Chalcidæ*. In addition, fungoid diseases are very prevalent in damp places and an enormous destruction may result if the conditions remain favourable to the spread of fungoid disease. With all these foes, one may imagine that even the enormous reproductive powers of this group are called upon to maintain their numbers and the curious way in which species become abundant in a locality and then disappear would be fully explained if we could observe the working of these enemies. Ants are not destructive to Coccids as is so frequently believed, but visit them to obtain their sweet excretion or to strip them of their mealy covering: in many cases ants build shelters for them, care for them, carry them about and treat them just as man does his domestic animals.

Few species are really destructive in India at the present time and the family has not the same importance it has elsewhere. It is chiefly to permanent crops such as tea, coffee, cacao, fruit, that these pests are injurious in other countries, and in India, the green bug (*Lecanium viride*), the brown bug (*Lecanium hemisphaericum*) and the Mealy bug (*Dactylopius citri*) are injurious to coffee, while a number of species occur on, but are not injurious to, tea. *Monophlebus* has been known to do damage to mango, jack and similar trees but this is a one-brooded species and is injurious only once every few years. *Aspidiotus aurantii* on orange, the species attacking sugar-cane (*Dactylopius sacchari*, *Ripersia sacchari*, *Aclerda japonica*), one species found on rice (*Ripersia sacchari*), and the potato Mealy bug (*Dactylopius nipae*) are the sole recorded cases of any importance. (See Mem. Agric. Dept., India, II, No. 7.)

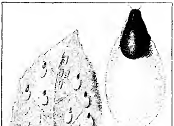

Fig. 530—CHIONASPIS THEÆ. MALE AND FEMALE scales on leaf; Female (above), male (below) scale, all magnified. (I. M. N.)

Coccids are abundant in all parts of the globe with their maximum development in tropical and sub-tropical regions. They have been spread on living plants and many species have a wide distribution. In many cases it is possible to clearly separate the indigenous and the introduced species and the spread of species now confined to their natural habitat will continue unless precautions are universally taken to prevent it. Of the 107 known Indian species, twenty-four are widely scattered and, though possibly originating in India, are more likely to have been introduced. Nine are doubtful and the remainder (74) are almost certainly indigenous and the number of indigenous species that remains to be discovered is probably a large one. In India, these insects occur generally, the greater number of indigenous species living on the diverse vegetation of the hill forests.

The literature of Indian species will be found in Indian Museum Notes (Vol. V), and in the Memoirs of the Agricultural Department (Vols. I and II). In Vol. II, No. 2, Green lists the known Indian species with a number of new species, and the life-histories and food-plants are summarised in a later Memoir, Vol. II, No. 7. The volumes on Coccidæ of Ceylon by E. E. Green should be consulted, as many Indian species are there discussed and beautifully figured. The student of the literature of economic Coccidæ outside India will find that the generic names are now extremely confused, owing to the substitution in Fernald's Catalogue of *Pseudococcus* for *Dactylopius*, *Coccus* for *Lecanium*, *Lepidosaphes* for *Mytilaspis* and *Dactylopius* for *Coccus*. We retain the old names (as Green has) and our *Lecanium* is the modern *Coccus* and our *Coccus* is the modern *Dactylopius*. No useful purpose has been gained by transferring generic names, but American and European Entomologists have in part or wholly adopted the changes, and the student must bear this very clearly in mind.

Eight sub-families are represented in India, the *Ortheziinæ*, *Idiococcinæ* and *Brachyscelinæ* not being known to occur. The total recorded species is 107, *Monophlebinæ* 14, *Asterolecaniinæ* 1, *Eriococcinæ* 2, *Dactylopinæ* 16, *Tachardiinæ* 4, *Coccinæ* 1, *Lecaniinæ* 30, *Diaspinæ* 35.

The *Monophlebinæ* are marked by the compound eyes of the males and the absence of the setiferous ring in the females. *Monophlebus* is represented by seven doubtfully distinct species. Both sexes grow to a great size (for this family), the females as much as two-thirds of an inch

The life-history of one species is fully described (Mem. Agric. Dept., India, Entom. II, 7), and all Indian species probably have a similar one. The young of both sexes appear during the cold weather and climb up bushes to feed. They moult as usual and the male in March, after the penultimate moult, struggles away into a corner and secretes a cloudy cocoon round itself; the legs and wings pads then appear and it becomes a pupa. The male emerges in early April and for a time is one of the abundant insects flying freely. (Plate LXXXIV.) The females are by this time entering the last instar and are fertilised now. They feed chiefly on the ends of branches of trees or on the stalks of such fruits as mango and jack. They grow to a very large size, flat active bugs clothed uniformly in mealy white wax. When full-grown they descend the tree and, when this is occurring, they are a very noticeable sight. In a week all have gone; actually each creeps away into hiding and lays eggs; the eggs lie there till November and then hatch. The curious life-history, the large size and, above all, their really extraordinary disappearance make this a very notable insect.

Icerya ægyptiaca, Dougl., is common on croton (Plate LXXXII) and the life-history of *I. minor*, Gr., is fully described (loc. cit.). Newstead has described *I. formicarum* from ants' nests. *Walkeriana cinerea*, Gr., is a large solid insect found upon babul (*Acacia arabica*) and mendhi (*Lawsonia alba*). The young are provided with very long hairs and float in the breeze like thistle-down. Of the *Asterolecaniinæ*, *Asterolecanium* includes *A. miliaris*, Boisd., var *robusta*, Gr., found in immense profusion on bamboo in Behar; the little pear-shaped scales are not easily seen, fixed tightly to the bamboo and not differing from it in colour. *Cerococcus hibisci*, Green, is a beautiful scale found upon cotton, hibiscus, etc. It is widespread in India; *Chalcid* parasites keep it in check. The *Eriococcinæ* include only two species found in the hills.

The *Dactylopiinæ* are the "mealy bugs" proper, the genera *Dactylopius* and *Phenacoccus* containing our common species. There is a definite setiferous ring and the abdomen is not cleft behind. The life-history of *D. saccharifolii* is described fully (loc. cit.): *D. citri*, Risso. (Plate LXXXII), is world wide, and is in Coorg injurious to the roots of young coffee plants. *D. nipæ*, Mask., is known on stored potatoes and on cotton, hibiscus, etc. *D. sacchari*, Ckll., lives on cane below the sheathing leaves. *D. virgatus*, Ckll., is common on Acalypha, violet and other garden plants. *Ripersia sacchari*, Gr., lives on cane, as also on rice and on grasses. *Phenacoccus insolitus*, Gr., has been found abundantly upon barlai (*Sida cordifolia*). *Antonina indica*, Green (fig. 527), is enclosed in a close felted sac, quite separate from the body; it is found on grasses.

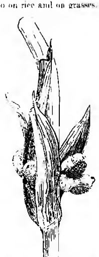

Fig. 527.—ANTONINA INDICA. FEMALES on grass stem. The right hand insect is extruding a drop of liquid. × 4. (F. M. H.)

The *Tachardiinae* include the lac insects, of which *Tachardia lacca*, Kerr. (Plate LXXXIII), is the most important, *T. fici*, Gr., and *T. albizziae*, Gr., also yielding lac on a commercial scale. It is by no means clear which lac is really *T. lacca* or how many species there really are. There is a considerable mass of literature on the lac insects but no really good account has yet been published. (A. J. I., Vol. IV, No. 3.) Of the *Coccinae* the Cochineal insect of commerce is *Coccus cacti*, said to have been introduced into South India. *C. indicus*, Green, has been found on *Opuntia* by I. H. Burkill.

The *Lecaniinae* have the body cleft behind and the anal orifice closed by a pair of triangular plates. Three important genera are included: *Lecanium* has no distinct covering but a hardened integument; no ovisac is formed; *Pulvinaria* is similar but a white ovisac is formed (Plate LXXXII, fig. 1); *Ceroplastes* is covered in solid wax, usually arranged in plates. *Lecanium hemisphaericum*, T. T., is the brown scale of coffee. *L. viride*, Gr., is the green scale of coffee. The former is common on guava in other parts of India. *L. hesperidum*, Linn., is the soft scale, found in the leaf-nests of the red tree-ant (*Oecophylla smaragdina*). *L. nigrum*, Nietn., is found on cotton, hibiscus, etc. *Pulvinaria psidii*, Mask. (Plate LXXXII), is the Green Mealy Scale which infests trees used as shade for Coffee in South India. *Ceroplastes*, the wax scale, is represented

PLATE LXXXIII.—TACHARDIA LACCA LAC.

Fig 1. Healthy insects on stick.
,, 2. Unhealthy ,, ,,
,, 3. First instar, active stage. x 40.
,, 4. Female, 4 weeks after inoculation. x 35.
,, 5. ,, 13 ,, ,, x 15.
,, 6. Dead female cell, with young emerging. x 4
,, 7. Male cell, 13 weeks after inoculation. x 15.
,, 8. Wingless male. x 12.
,, 9. Winged male. x 10.

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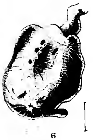

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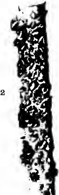

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and other garden plants. *Ripersia sacchari*, Gr., lives on cane, as also on rice and on grasses. *Phenacoccus insolitus*, Gr., has been found abundantly upon barlar (*Sida cordifolia*). *Antonina indica*, Green (fig. 527), is enclosed in a close felted sac, quite separate from the body: it is found on grasses.

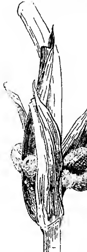

Fig. 531—ANTONINA INDICA FEMALES on grass stem. The right-hand insect is extruding a drop of liquid. × 3. (F. M. H.)

The *Tachardiinæ* include the lac insects, of which *Tachardia lacca*, Kerr. (Plate LXXXIII), is the most important, *T. fici*, Gr., and *T. albizziæ*, Gr., also yielding lac on a commercial scale. It is by no means clear which lac is really *T. lacca* or how many species there really are. There is a considerable mass of literature on the lac insects but no really good account has yet been published (A. J. I., Vol. IV, No. 3.) Of the *Coccinæ* the Cochineal insect of commerce is *Coccus cacti*, said to have been introduced into South India. *C. indicus*, Green, has been found on *Opuntia* by I. H. Burkill.

The *Lecaniinæ* have the body cleft behind and the anal orifice closed by a pair of triangular plates. Three important genera are included: *Lecanium* has no distinct covering but a hardened integument: no ovisac is formed: *Pulvinaria* is similar but a white ovisac is formed (Plate LXXXII, fig. 1): *Ceroplastes* is covered in solid wax, usually arranged in plates. *Lecanium hemisphæricum*, T. T., is the brown scale of coffee. *L. viride*, Gr., is the green scale of coffee. The former is common on guava in other parts of India. *L. hesperidum*, Linn., is the soft scale, found in the leaf-nests of the red tree-ant (*Oecophylla smaragdina*). *L. nigrum*, Nietn., is found on cotton, hibiscus, etc. *Pulvinaria psidii*, Mask. (Plate LXXXII), is the Green Mealy Scale which infests trees used as shade for Coffee in South India. *Ceroplastes*, the wax-scale, is represented commonly by *C. floridensis*, Comst., on guava. The wax of *C. ceriferus*, Anders., has been used in India as medicine, etc. (Ind. Mus. Notes, II, No. 3.)

The *Diaspinæ* are marked by the pygidium, a complex terminal segment with the anal orifice above and the genital orifice below, with wax glands grouped around both, and on the margin, a complicated series of spines and processes. The identification of species is rendered possible by the pygidium.

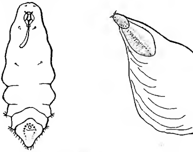

Fig. 532—CHIONASPIS SEPARATA, FEMALE AND PUPARIUM. (*After Green.*)

The covering of the female consists of the first small exuvium (pellicle), to which is added the second exuvium (pellicle) and in most cases a large felted scale (secretionary supplement); in the male there is the first pellicle and a felted scale. Our genera can be distinguished by the characters of these scales more or less clearly as follows:—

Aspidiotus.	Male and female puparium similar, subcircular.
Mytilaspis.	Male and female puparium similar, elongate.
Parlatoria.	Male and female puparium similar, broadly oval.
Aonidia.	Male and female puparium similar, subcircular. Female puparium composed of second pellicle, no secretionary supplement.
Diaspis.	Female puparium subcircular, male elongate.
Chionaspis.	Female puparium elongate or pyriform. Male elongate.
Fiorinia.	Female puparium with no secretionary supplement. Male elongate.

PLATE LXXXIV.—Monophlebus Stebbingi Var. Octocaudata Gr.

Fig. 1. Adult Female, after the last moult.
" 2. Exuviæ of Nymphs.
" 3. Female showing ovisac.
" 4. Females egg-laying under a piece of brick.
" 5. Male pupa.
" 6. Male Imago.
" 7. *Aulis vestita*, larva, magnified.
" 8. " " pupa, "
" 9. " " imago.

Figs. 7, 8, 9, illustrate the Coccinellid beetle which specially preys upon this mealy-bug.

(Reprinted from Memoirs of the Agricultural Department.)

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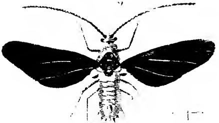

Aspidiotus aurantii, Mask., is the red Scale of Orange, a world-wide species growing on cultivated citrus. *A. destructor*, Sign., is frequently

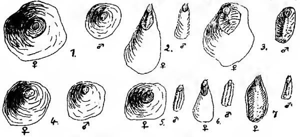

Fig. 533—FEMALE AND MALE PUPARIA OF DIASPINÆ. 1. ASPIDIOTUS. 2. MYTILASPIS. 3. PARLATORIA. 4. AONIDIA. 5. DIASPIS. 6. CHIONASPIS. 7. FIORINIA.

abundant on palms and on mango. *A. ficus*, Ashm., is the black Scale of the Areca palm. *Mytilaspis piperis*, Gr., was found on croton at Calcutta, and by Dr. Barber on cultivated pepper in South India.

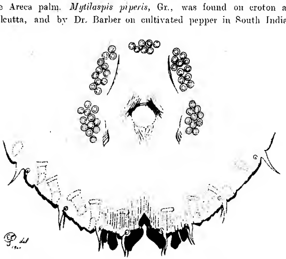

Fig. 534—CHIONASPIS DECURVATA, GREEN. PYGIDIUM. (I. M. N.)

We figure *Diaspis Barberi*, Gr. (Plate LXXXII, fig. 3), which grows on *Loranthus* on trees. *Chionaspis vitis*, Gr., is frequently to be seen on the leaves of mango trees: two species of *Hemichionaspis*, *H. fici*, Gr., and *H. minima*, Gr., infest the fig trees so constantly grown as shade.

PEDICULIDÆ.—(*Anoplura*) *Lice.*

Wingless flattened parasitic blood-sucking insects. The head distinctly separated from the thorax; the three segments of the latter fused into one mass. The proboscis short, not folded back under the thorax. The legs stout, generally with very large claws.

Lice are common parasites of men and mammals, and their characteristic flattened shape and big claws make them easily recognised. It is possible to confuse them with the non-blood-sucking Mallophaga, as a few species of the latter are found on mammals though they are mostly confined to birds. The Mallophaga differ from the *Pediculidæ* in having jaws instead of a proboscis, and in the thoracic segments being usually fairly distinct; as a rule the head is relatively much larger than in *Pediculidæ*, and the claws smaller. Very little seems to be known about the life-history of Lice. The males are generally a little smaller than the females, and can sometimes be distinguished by their having the end of the abdomen rounded whereas the female abdomen is often divided by a median notch or cleft. They are very prolific and probably most species will be found to pass their lives on the body of their host, though some of them apparently do not do so. Three species infest man, and are common in India. These are *Phthirius inguinalis*, Leach, the crab-louse; *Pediculus capitis*, DeGeer., the head-louse; and *P. vestimenti*, Burm., the body-louse. Other species occur on horses, cattle, goats, pigs, camels, dogs, etc.

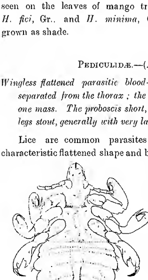
Fig. 535—HÆMATOPINUS OF BUFFALO.

Giebel ("*Insecta Epizoa*") separates the Lice into four genera according to the following characters :—

A. Antennæ five-jointed.
  (1) Thorax not sharply separated from abdomen. *Phthirius*.
  (2) Thorax sharply separated from abdomen.
    (*a*) Thorax almost as broad as abdomen .. *Pediculus*.
    (*b*) Thorax a good deal narrower than the broad abdomen .. .. *Hæmatopinus*.
B. Antennæ, three-jointed .. .. *Pedicinus*.

Of these four genera the first two comprise the human parasites. *Pediculus capitis* is very similar to *P. vestimenti*; the latter however has antennæ a little longer than in *P. capitis*, and the second antennal joint a little longer than the others, while in *P. capitis* all the antennal joints are about the same length. Species of the genus *Pedicinus* are found on monkeys, while in this classification *Hæmatopinus* comprises all the lice found on other warm-blooded animals. The Indian species of this last genus are evidently fairly numerous, but they have not been worked out.

The interest of the group has been considerably increased by the discovery that Pediculi may act as carriers of a fever-producing parasite. (Mackie, B. M. J.)

The most recent classification by Dalla Torre (Genera Insectorum Fasc. 81) is considerably more elaborate than Giebel's. He regards the Anoplura as composed of four families differentiated as follows :—

A. Legs not provided with clasping claws; tibiæ and tarsi slender, the latter without any thumb-like process. Mouth at the extremity of a long tubular process.
  Antennæ 5-jointed .. .. *Hæmatomyzidæ*.
  including the Indian Elephant's louse. *Hæmatomyzus elephantis*.
B. Legs with clasping claws, tibiæ stout with a thumb-like process. Antennæ 3 to 5-jointed. Body flattened. A stigma on the mesothorax and on abdominal segments 3-8—
    Eyes large, dark and prominent .. *Pediculidæ*.
    Eyes obscure or absent .. *Hæmatopinidæ*

C. Antennæ 4-5-jointed. Body thick and plump. A stigma on the meso- and metathorax and on abdominal segments 2-8. Head wide, no eyes. The body sometimes covered with thick spines. *Echinophthiriidæ.*

Of these families, the Pediculidæ comprise the sub-families *Pedicininæ* and *Pediculinæ*, the latter composed of the genera *Pediculus* and *Phthirus* (*Phthirius*). *Hæmatopinidæ* includes sub-families *Hæmatopininæ* (genus *Hæmatopinus*), *Linognathinæ* (genera *Polyplax*, *Hoplopleura*, *Linognathus*, *Hæmodipsus* and *Solenopotes*) and *Euhæmatopininæ* (genera *Euhæmatopinus* and *Hæmatopinoides*). *Echinophthiriidæ* contains three aberrant genera found on seals and walruses. No species is definitely recorded by Dalla Torre as Indian. (F. M. H.)

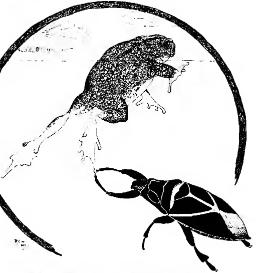

Fig. 336—Belostoma and a Toad. (R. C. Wood.)

PLANT INDEX.

In this index, every plant occurs under the generic name, in italics, and under familiar common names, English or Indian. For instance, wheat occurs under "*Triticum*" and "Wheat;" Castor under "Castor," "Endi" and "*Ricinus*." For those who do not know English or Indian names the generic name should be sought; for workers in India, the common English or Indian name is the easiest to find, if there is one, but no attempt is made to list the multitudinous Indian names of the whole continent. The index is meant to assist (1) the collector who finds an insect on mango or ber; (2) the scientist outside India, who wants to look up the insects found on *Mangifera*. Both are advised also to consult the plant index of Indian Insect Pests.

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INDEX.

In this index, two main objects are considered; first, the indexing of all genera, so that anyone getting an insect identified as say *Dindymus concolor*, can find where *Dindymus* should be placed; second, topics discussed in any detail, such as "Sex" or "Silk" are indexed, so that the interlude can be readily found. The index does not go beyond this, as the book is primarily an account of families in definite order, which can be readily found, and the possible index heads turning up in the text are of no importance. Every family, sub-family and genus is indexed, but only for its systematic place and genera mentioned in interludes are not indexed. All sub-families have been omitted in cases where the next entry on the index is the genus from which the sub-family takes its name, *and both have the same page reference*. Thus of "Bostrychidæ, 313," "Bostrychinæ 316," and "Bostrychus, 316," the second has been struck out. All references are to pages if in Arabic numerals, to plate if in Roman figures.

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